2017

Potential Impact of Climate Change Induced Sea Level Rise on Livelihood Security in Coastal Bangladesh

Roy, Susanta Kumar

University of Rajshahi

Potential Impact of Climate Change Induced Sea Level Rise on Livelihood Security in Coastal Bangladesh

A Dissertation Submitted to the Institute of Bangladesh Studies in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy in Geography

Researcher

Susanta Kumar Roy
PhD Fellow, Session: 2014-2015
Institute of Bangladesh Studies
University of Rajshahi

Supervisor

Dr. Shitangsu Kumar Paul
Professor
Department of Geography and Environmental Studies
University of Rajshahi

Institute of Bangladesh Studies
University of Rajshahi, Bangladesh

June 2017

Certificate

This is to certify that the dissertation entitled "Potential Impact of Climate Change Induced Sea Level Rise on Livelihood Security in Coastal Bangladesh" submitted by Susanta Kumar Roy, PhD Fellow of the session 2014-2015 to the Institute of Bangladesh Studies, University of Rajshahi, Bangladesh for the degree of Doctor of Philosophy in Geography is an original research work done under my supervision and guidance. To the best of my knowledge, this dissertation was not previously submitted for any diploma/degree/fellowship to any other University/Institute. Materials obtained from primary and secondary sources have been duly acknowledged in this dissertation.

Dr. Shitangsu Kumar Paul
Supervisor
&
Professor
Department of Geography and
Environmental Studies
University of Rajshahi
Rajshahi, Bangladesh

Declaration

I do hereby declare that the dissertation entitled "Potential Impact of Climate Change Induced Sea Level Rise on Livelihood Security in Coastal Bangladesh" submitted to the Institute of Bangladesh Studies, University of Rajshahi, as part of the requirements for the degree of Doctor of Philosophy in Geography is my original work. Neither the whole nor any part of it was submitted to any other university or institute for any other degree or diploma or other purposes. My indebtedness to other works has duly been acknowledged at the relevant places.

Susanta Kumar Roy
PhD Researcher
Session: 2014-2015
Institute of Bangladesh Studies
University of Rajshahi
Rajshahi, Bangladesh

Acknowledgments

This dissertation is an outcome of three years efforts as a PhD fellow at the Institute of Bangladesh Studies, University of Rajshahi, Rajshahi, Bangladesh. There is an endless list of organizations and people to whom I am greatly indebted, without whom this dissertation could not be initiated and completed. I would firstly thank the Institute of Bangladesh Studies, University of Rajshahi that has given me an opportunity to carry out this PhD programme. Special thanks go to Ministry of Education, Bangladesh, Directorate of Secondary and Higher Education, Bangladesh and University Grant Commission, Bangladesh for providing me formal and other supports during my study.

In expressing acknowledgements at first, I would like to express my heartiest gratitude to Dr. Shitangsu Kumar Paul. I am greatly indebted to him for his guidance, keen supervision and encouragement that helped me to start and complete this research. His insightful comments have enriched the research significantly. I strongly feel that the accomplishment of this research would not have been come out as a reality without his constant encouragement and caring attitudes towards me.

I would particularly like to thank Prof. Dr. Swarochish Sarker, Director, Institute of Bangladesh Studies, University of Rajshahi, for his valuable suggestions, guideline, scholarly support and encouragement. He always inspired me for completing my research work timely.

I am indebted and grateful to Prof. Dr. M. Zainul Abedin, Prof. Dr. M Shahidullah (Ex Director, IBS, and University of Rajshahi) and Prof. Dr. Jakir Hossain who have provided me huge supports to complete my research work.

I must note my absolute gratefulness to Dr. M Mostafa Kamal, Dr. Mohammad Najimul Haque and Dr. M. Kamruzzaman for their friendly approach and enthusiastic cooperation who are the faculty members of the Institute of Bangladesh Studies, University of Rajshahi. Without their direct help and constant encouragement this research work would not have been come out as reality.

Special gratitude goes to Dr. M. Mizanur Rahman, Professor, Department of Geography and Environmental Studies, University of Rajshahi who provided me guideline and precious suggestions as reviewer on registration and conversion seminar respectively.

I am grateful to the Department of Geography and Environmental Studies, University of Rajshahi, IBS Library, Dhaka University Library, Rajshahi University Library, BIDS Library, BBS Library from those I gained knowledge and support for the development of the dissertation.

I am grateful to the scholars of Institute of Bangladesh Studies of different sessions, especially scholars of session 2014-2015. They helped me always, to whom I have gone any time without any hesitation for any kind of help. Thanks to all officers and staffs of the IBS for their well wishes and cooperation.

Special appreciation goes to respective UNO of the study area for their supports and valuable opinions which enriched the thesis. I am grateful to the coastal people who gave their valuable time for interview.

My mother Kanan Bala Roy entails a very special place in this acknowledgement, as without her courageous support I could have never completed my dissertation. Her praying, loving and caring have provided me with huge confidence to embark on and finish this PhD journey.

I would like to express my wholehearted gratitude to my wife Mousumi Halder for her continuous inspiration and cooperation who had taken all the responsibilities of the family on her shoulder. My daughter Srishty Roy and son Anindya Roy deserve very special thanks for their cooperation who have been deprived from their father's affection and love during the research period.

Finally, I thank all the friends, colleagues and well-wishers who have contributed directly or indirectly for the completion of the research work.

Susanta Kumar Roy

Abstract

A clear relationship between global warming and the risk of climate change induced sea level rise has already been identified in various studies around the globe. The effect of the event is destruction to human and economic development which includes livelihood insecurity. The consequences of sea level rise pose a serious threat to the natural resource based livelihood opportunities of low lying coastal communities. In addition to recurrent and rapid onset of different extreme events (i.e. flood, cyclone etc.) coastal zone has to confront with a range of creeping risks. Increasing rates of sea level rise caused by global warming are expected to lead to permanent inundation, drainage congestion, salinity intrusion and frequent storm surge inundation. Climate change induced sea level rise is a massive threat to all aspects of human development and achievement.

Bangladesh being a low-lying deltaic coast is very much vulnerable to SLR and its associated events. Moreover, it is one of the most densely populated countries of the world where 28% of the population live in the coastal area. So it is imperative to know the impact of disaster of impending dangers earlier such as sea level rise for effective adaptation measures. The study has explored a number of fundamental aspects for example the potential impact of SLR in coastal Bangladesh, the thinking and perceptions of coastal people regarding the impact of SLR in their livelihood, the adaptation measures etc.

The coastal region of Bangladesh is divided into three major regions as east, central and western coastal zone. The study was conducted based on both primary and secondary data. This empirical research has been conducted in six unions of three upazila of three districts of the coastal zone of Bangladesh. The study areas were selected by simple random sampling. A sample survey of 380 households was done. Respondents were interviewed using a semi-structured questionnaire during June-October 2016. Questionnaire survey was supplemented by focus group discussion and key informant interviews. Questionnaire was made based on various dimensions of climate awareness and consulting some much cited global literatures. To find out the potential impact of SLR on livelihood securities, different livelihood capital related questions of coastal people were included in the questionnaire. To find out exposed region of the study area a comparative analysis has been done among the different livelihood capitals.

Respondents' perception about the vulnerability (impact dimensions) of SLR and its associate events on their livelihood security are measured in a 5-point Likert scale. Questionnaire included 27 impact-responses to major categories of livelihood insecurity which revealed livelihood security perception of the respondents.

Livelihood securities of coastal population is measured using various indicators in which results from regression analysis revealed food security of coastal zone is controlled by several predictors such as occupation of respondents, year of schooling of house wife, amount of land, age and different livelihood capitals. Research results also strongly revealed that a significant part of coastal populations will be SLR refugees by the year 2100 and this may eventually trigger up huge out migration and destroy livelihood security system of the coastal region.

The major findings of the study revealed that agricultural livelihood, fish sector, housing and settlement, food security, water and sanitation, health care facilities are vulnerable segments to sea level rise impacts. The study also explored that people find some indigenous adaptation strategies to combat in sea level rise consequences, though some institutional efforts are found in strengthening adaptation mechanism in the study areas. Adaptation and coping strategies vary depending on the occupation. Respondents engaged in agriculture and allied occupations are in constant threat of climatic disastrous events.

Moreover, Respondents identified wide range of measures for positive adaptation and most of such measures are related to minimization of both exposure and sensitivity, and maximization of adaptive capacity. In different situations of SLR adaptation strategies, responses were analyzed through multiple response analysis. Major strategies were found in agricultural management, fisheries management, salinity management, settlement management, land use management and non-agricultural activities management.

Necessary adaptation policies and an action plan for effective implementation is immediately needed to face the crucial challenges to environment, food security and occupational security. Successful adaptation depends on the actions and capacities of local government institutions because local government plays a vital role in mediating access to scarce resources, providing basic services and ensuring appropriate protection from natural disasters. Finally, SLR is a phenomenon created by the industrially developed countries and Bangladesh is the worst victim of it. Therefore, the global community and multi-lateral and bi-lateral development agencies must come forward to support Bangladesh in formulating and implementing appropriate adaptation policies to combat this massive environmental threat to make resource-poor coastal communities of Bangladesh more resilient.

Contents

Certificate i
Declaration ii
Acknowledgments........ iii
Abstract v
Contents........ vii
Contents of Appendices xiv
Contents of Tables xv
Contents of Figures xx
Contents of Abbreviations........ xxi
Glossary........ xxii

Chapter One : Background of the Study 1

1.1 Introduction 1
1.2 Problem Statement........ 3
1.3 Operational Definition of the Key Terms 6
1.4 Present Scenario of Sea Level Rise (SLR)........ 8
1.4.1 Climate Change and Sea Level Rise 8
1.4.2 Impact of Climate Change Induced Sea Level Rise on Bangladesh........ 10
1.5 Research Gap........ 12
1.6 Research Questions........ 13
1.7 Objectives of the Study........ 13
1.8 Justification of the Study........ 13
1.9 Scope of the Study........ 15
1.10 Limitation of the Study 16
1.11 Theoretical Approaches and Conceptual Framework........ 16
1.12 Feasibility of the Study 23
1.13 Utility of the Study 24
1.14 Organization of the Dissertation........ 24
1.15 Chapter Summary........ 25

Chapter Two : Literature Review 26

2.1 Introduction 26

2.1.1 Reviews on Relevant Concepts of Climate Change 27

2.1.2 Reviews Related to Climate Change induced Sea Level Rise 29

2.1.3 Reviews Related to Sea Level Rise and Salinity Intrusion 32

2.1.4 Reviews Related to Sea Level Rise and Livelihood Security........................34

2.1.5 Concept of Sustainable Livelihood and Livelihood Security 40

Chapter Three : Research Methodology..44

3.1 Introduction 44

3.2 Nature of the Study 44

3.3 Sources of Data 44

3.4 Sampling Techniques 45

3.4.1 Selection of Study Area 45

3.4.2 Types of Respondents 50

3.5 Sample Distribution 51

3.6 Data Collection Techniques 53

3.6.1 Reconnaissance Survey 53

3.6.2 Semi-structured Interview with Key Informants 53

3.6.3 Questionnaire Survey 54

3.6.4 Field Observation 54

3.6.5 Focus Group Discussion 54

3.7 Data Analysis Process 54

3.7.1 Quantitative Analysis 55

3.7.2 Qualitative Analysis 56

3.8 Reliability and Validity of Data..60

3.9 Ethical Considerations 61

Chapter Four : Study Area and Respondents Profile 62

4.1 Introduction 62

4.2 Geophysical Setting 62

4.2.1 Area and Location 62

4.2.2 Demographics Description 63

4.2.3 Sociopolitical Settings 63

4.3 Climate of the Study Area 65

4.4 Profile of Respondents 66

4.4.1 Age Structure, Years of Living and Places of Origin of Respondents.....66

4.4.2 Year of Living of Household Head by Unions 68
4.4.3 Gender of the Household Head and Household Size 69
4.4.4 Household Size of the Respondents 69
4.4.5 Education 70
4.4.6 Land Ownership 71
4.4.7 Religion of the Respondents 72
4.4.8 Income 73
4.5 Major Livelihood Groups...74
4.6 Housing Pattern 75
4.7 Chapter Summary 76

Chapter Five : Potential Impact of Sea Level Rise on Livelihood in Coastal Bangladesh 78

5.1 Introduction 78
5.2 Sea level Rise Consequences in Bangladesh..78
5.3 Potential Impact on Livelihood Security of Sea Level Rise in Bangladesh 81
5.4 Livelihood Affecting Impact of CC-SLR: A Comparative Analysis in the Study Area 84
5.4.1 Biotic Impact...84
5.4.1.1 Impacts on Agriculture 84
5.4.1.2 Impacts on Health 88
5.4.1.3 Impacts on Tourism 91
5.4.1.4 Impacts on Fisheries and Aquaculture 92
5.4.2 Abiotic Impact...95
5.4.2.1 Increase of Salinity Intrusion 95
5.4.2.2 Impacts on Landmass Due to SLR 97
5.4.2.3 Impacts on Settlement..100
5.4.2.4 Impacts on Salt Farming 101
5.4.2.5 Impacts on Ecological Unit 102
5.4.2.6 Increasing Natural Disaster 104
5.4.2.7 Increasing Intensity of Monsoon Flooding 105
5.4.2.8 Declining Soil Quality 106
5.4.2.9 Species Extinction 108
5.4.2.10 Coastal Erosion...108
5.4.2.11 Increasing of Water Logging...109
5.4.3 Socio-Economic Impact of Sea Level Rise 110
5.4.3.1 Impacts on Basic Needs 111
5.4.3.2 Impact on Infrastructure...113

5.4.3.3 Emergence of Climate Refugee 113
5.4.3.4 Loss of GDP and Appearance of Macroeconomic Stress 114
5.4.3.5 Impact on Education System 116
5.4.3.6 Appearance of Climate Poverty 117
5.4.3.7 Loosing Valuable Natural Resources 118
5.4.3.8 Reduction of Social Welfare 118
5.5 Statistical Assessment of SLR Impact 119
5.6 SLR Impact on Macro-economic Loss in the Study Area: Regression Result 120
5.7 Chapter Summary 122

Chapter Six : Households Assets Portfolio and Livelihood Strategies 125

6.1 Introduction 125
6.2 Livelihood Assets and Strategies 125
6.3 Assessing Livelihood Capitals 126
6.4 Livelihood Capitals and Asset Pentagon 135
6.5 Major Livelihood Groups and Strategies 138
6.6 Major Livelihood Affecting Adversity and Crisis in the Study Unions 142
6.7 Income Diversification 143
6.8 Chapter Summary 144

Chapter Seven : Coping and Adaptation to Potential Impact of SLR 146

7.1 Introduction 146
7.2 Defining Adaptation and Concept 147
7.3 Strategy and Approach to Successful Adaptation 148
7.3.1 Adaptation Measures Proposed by IPCC 148
7.3.2 Adaptation Options Practiced Worldwide to Reduce Sea Level Rise Impact 149
7.4 Types of CC- Induced Hydro Meteorological Hazards in Coastal Zone ... 149
7.5 Awareness about Climate Change for Adaptation 151
7.6 Coping and Adaptive Measures to Secure Livelihoods 155
7.6.1 Indigenous Adaptation Practices in the Study Areas 156
7.6.1.1 Adaptation Measures for Agriculture due to Salinity Intrusion in Different Scenarios SLR 157
7.6.1.2 Adaptation Strategies for Crops Management in Different Scenarios of Potential Impact of Sea Level Rise 158
7.6.1.3 Adaptation Measures for Fisheries in Different Scenarios of Potential Impact of Sea Level Rise 160

7.6.1.4 Adaptation Measures for Settlement in Different Stages of Potential Impact of Sea Level Rise 162
7.6.1.5 Adaptation Measures for Land Use in Different Scenarios of Potential Impact of Sea Level Rise 164
7.6.1.6 Nonagricultural Activities Adaptation Different Scenarios of Potential Impact of Sea Level Rise 165
7.6.1.7 Occupational Adaptation in Different Scenarios of Potential Impact of Sea Level Rise 167
7.6.2 Institutional Initiatives for Adaptation 169
7.6.2.1 Adaptation Measures Taken by Government Organization in Study Areas 169
7.6.2.2 NGOs Involvement in Adaptation Sector 173
7.6.2.3 Community Based Adaptation Strategies 176
7.7 Statistical Assessment of Coping and mitigation for SLR 177
7.8 Challenges for Coping and Adaptation 181
7.9 Chapter Summary 183

Chapter Eight : Institutional Mechanism for SLR Induced Disaster Mitigation and Livelihood Security 186

8.1 Introduction 186
8.2 CC Induced Disaster Risk Reduction in Bangladesh: A Brief Overview on the Perspective of Household Coping, Adaptation and Livelihood Security 186
8.3 Information Regarding SLR Threat at Community Level: Issues of Enhancing Adaptive Capacity 188
8.4 Key Units of the Country Involved in Sea Level Rise Adaptation 189
8.4.1 Ministry of Environment and Forests 189
8.4.2 Ministry of Agriculture 189
8.4.3 Ministry of Water Resources 189
8.4.4 Ministry of Local Government, Rural Development and Cooperatives (LGRD) 190
8.4.5 Ministry of Food and Disaster Management 190
8.4.6 Ministry of Fisheries and Livestock 190
8.4.7 Local Government Institutions Involved in Sea Level Rise Adaptation in Study Areas 190
8.5 Assistance for Sea Level Rise Risk Reduction, Coping, Adaptation on Livelihood Security: A Discussion Based on Household Survey 191
8.5.1 Community Awareness Programs and Preparedness Measures in Study Unions 191
8.5.2 Dissemination of SLR Information and Community Preparedness in the Study Unions 193

8.5.3 Disaster Risk Reduction through Enhancing Community Coping, Resiliency and Rebuilding Livelihoods....196
8.5.4 Foreign Assistance to Combat Climatic Disaster in the Study Area....199
8.5.5 Satisfaction Level of Respondents about Foreign Support....199
8.5.6 Level of Satisfaction on Provided Service and Information by Different Organizations....200
8.6 Chapter Summary....201

Chapter Nine : Assessing Livelihood Security....204

9.1 Introduction....204
9.2 Determining Livelihood Security: Conceptual Considerations....205
9.3 Measuring Household Food Security: Discussion on Sample Households....207
9.4 Determinants of Food Security and Measuring Techniques: A Brief Review....208
9.5 Household Food Security for Impending Impact of SLR: Subjective Measures....209
9.5.1 Household Food Availability....210
9.5.2 Household's Perception about Adequacy of Food Consumption Per Day....211
9.5.3 Household’s Anxiety for Future Food Consumption....212
9.5.4 Measuring Household Food Security Based on Per Capita per Day Calorie Consumption....213
9.6 Household Nutritional Security: Nutritional Status of Women at Reproductive Age and Under Five Years of Children....219
9.6.1 Body Mass Index for Women of Reproductive Age....219
9.6.2 Weight for Height of Under Five Years of Children....221
9.6.3 Weight-for-Age of Under Five Children....223
9.6.4 Height-for-Age of Under Five Children....224
9.7 Economic Security of Household....225
9.7.1 Annual Household Income Flow....225
9.7.2 Household Annual Expenditure....228
9.7.3 Household Debt Level: An Alternative of Economic Security....229
9.7.4 Household Savings Level....231
9.8 Household’s Shelter, Water and Sanitation Security....233
9.8.1 Shelter Security....233
9.8.2 Electricity Connection in Housing Unit....235
9.8.3 WATSAN Infrastructure: Access Sanitation and Drinking Water....236
9.8.4 Household Sanitation Security....237

9.8.5 Drinking Water Facility 238
9.9 Household Health Security 240
9.9.1 Immunization of Children 240
9.9.2 Deaths of Children During Childhood 241
9.9.3 Type of Medicare Facilities Enjoyed by Household by Union 242
9.10 Household Educational Security 243
9.11 Livelihood Security Exploration Due to Potential Impact of Sea Level Rise in Coastal Region 244
9.12 Chapter Summary 246

Chapter Ten : Summary and Conclusion 249

10.1 Summary of Findings 250
10.1.1 Potential Impacts of Climate Change Induced Sea Level Rise 250
10.1.2 Assets Portfolio and Livelihood Strategies 252
10.1.3 Indigenous Adaptation Strategies for the Impact of Sea Level Rise on Livelihood Security 254
10.1.4 Institutional Support Mechanism for SLR Induced Disaster Mitigation and Livelihood Security 257
10.1.5 Livelihood Security of Coastal People Against SLR 259
10.2 Conclusion 263
10.3 Policy Recommendations 264
10.4 Future Direction of Research 266

Appendices 267

Bibliography 296

Contents of Appendices

Appendix A : Tables of Findings 267
Appendix B1 : Household Survey Questionnaire 272
Appendix B2 : Check List for GOs and NGOs Interview 287
Appendix B3 : List of participants in Focus Group Discussion (FGD) 289
Appendix C : NGOs Working in Study Area.. 290
Appendix D : Photograph.. 291

Contents of Tables

Table 1.1: Global Warming (GW) and Sea Level Rise (SLR) Scenario 8

Table 1.2: Sea Level Rise (SLR) Scenarios in Bangladesh and Its Possible Impacts ...11

Table 3.1: For determining sample size, demographic scenario of the study area is required which is as under 51

Table 3.2: Organizational Personnel..52

Table 3.3: Experts of Climate Change Induced Sea Level Rise 52

Table 3.4: Summary Table 53

Table 4.1: Distribution of Household Head by Age 67

Table 4.2: Place of Origin of Living of Household Head by Unions 68

Table 4.3: Year of Living of Household Head by Unions 68

Table 4.4: Distribution of Household Head by Gender 69

Table 4.5: Household Size of the Respondents 70

Table 4.6: Adult Literacy Rate in Shymnagar, Kalapara and Cox's bazar Sadar upazilla Upazila and Bangladesh 70

Table 4.7: Education Level of Household Head by Village 71

Table 4.8: Landownership Pattern of Households by Unions.....................................72

Table 4.9: Religion of Household Head by Unions..73

Table 4.10: Income Level of Households by Study Unions 74

Table 4.11: Major Livelihood Group-wise Household Distribution 75

Table 5.1: Types of Possible Livelihood Insecurity due to Sea Level Rise in the Coastal Zone of Bangladesh 83

Table 5.2: Effect of 1 m Sea Level Rise on Agriculture (major crops)........................85

Table 5.3: Present Soil Salinity Range in Study Area 86

Table 5.4: Loss of Production in Crop Agriculture 88

Table 5.5: Present Nutritional Status in Study Area...90

Table 5.6: Prevalence of Waterborne Diseases due to Sea Level Rise.........................91

Table 5.7: Decrease to Tourism Opportunities 92

Table 5.8: Loss of Production in Fisheries and Aquaculture 94
Table 5.9: The Salt Affected Area from 1973 to 2009 in Coastal Areas 95
Table 5.10: Land Use Pattern of Study Area 96
Table 5.11: Impact Due to Salinity Intrusion 97
Table 5.12: Present Top Soil Texture Status in Study Area 99
Table 5.13: Impact on Landmass Due to SLR 100
Table 5.14: Impact on Human Settlements Due to SLR 101
Table 5.15: Fate of the Sundarbans with Different Scenarios of Sea Level Rise 103
Table 5.16: Impacts on Ecological Unit 104
Table 5.17: Increase of Natural Disaster Due to SLR 105
Table 5.18: Monsoon Flooding Due to Sea Level Rise 106
Table 5.19: General Soil Types in Study Area 107
Table 5.20: Decline in Soil Quality Due to Sea Level Rise 108
Table 5.21: Coastal Erosion Due to Sea Level Rise 109
Table 5.22: Coastal Erosion Due to Sea Level Rise in Different Situation 109
Table 5.23: Water Logging Due to Sea Level Rise 110
Table 5.24: Impacts of Sea Level Rise on the Basic Needs 112
Table 5.25: Impact on Basic Needs Due to Sea Level Rise 113
Table 5.26: Emergence of Climate Refugee 114
Table 5.27: National Damage Estimation for Sea Level Rise 115
Table 5.28: Regional Damage for SLR of 0.1m, 0.25m, 0.3m and 1.0m (in million BDT) 115
Table 5.29: Loss of GDP and Occurrence of Macroeconomic Pressure 116
Table 5.30: Impact on Education System due to Sea Level Rise 117
Table 5.31: Increase of Poverty Rate due to Sea Level Rise 118
Table 5.32: Reduction of Social Welfare Due to Sea Level Rise 119
Table 5.33: Correlation Matrix of Financial Losses among Different Variables 119
Table 5.34: Correlation among Different Variables of Impact 120
Table 6.1: Indicators and Measuring Scale of Human Capital 128
Table 6.2: Indicators and Measuring Scale of Natural Capital 129
Table 6.3: Indicators and Measuring Scale of Physical Capital 131

Table 6.4: Indicators and Measuring Scale of Access to Mass Communication and Individual Communication 133

Table 6.5: Indicators and Measuring Scale of Participation and Connection 134

Table 6.6: Indicators and Measuring Scale of Membership Status in Groups 135

Table 6.7: Livelihood Assets Index by Village and Livelihood Groups 137

Table 6.8: Distribution of Major Livelihood Groups in Coastal Bangladesh 139

Table 6.9: Major Livelihood Groups in Study Villages 139

Table 6.10: Major Adversity and Crisis in a Year in the Study Unions 143

Table 6.11: Comparative Aspects of Livelihoods in Six Study Unions 144

Table 7.1: Adaptation Measures Proposed by IPCC 149

Table 7.2: Adaptation Options Practiced Worldwide to Reduce Sea Level Rise Impact 149

Table 7.3: Characteristics of Natural Disastrous Events in the Study Area 151

Table 7.4: Perception about Climate Change 152

Table 7.5: Sources of Information about the Potential Impact of SLR 153

Table 7.6: Number of Hazardous Events Round the Year 154

Table 7.7: Adaptation Measures for Agriculture due to Salinity Intrusion in Different Scenarios SLR 158

Table 7.8: Adaptation Strategy for Crops Management in Different Stages of Potential Impact of Sea Level Rise 160

Table 7.9: Adaptation Measures for Fisheries in Different Scenarios of Potential Impact of Sea Level Rise 161

Table 7.10: Adaptation Measures for Settlement in Different Scenarios of Potential Impact of Sea Level Rise 163

Table 7.11: Adaptation Measures for Land Use in Different Scenarios of Potential Impact of Sea Level Rise 165

Table 7.12: Nonagricultural Activities and Adaptation for Different Scenarios of Potential Impact of Sea Level Rise 167

Table 7.13: Occupational Adaptation in Different Stages of Potential Impact of Sea Level Rise 168

Table 7.14: Correlation between Income Level and SLR Coping Strategies 178

Table 7.15: Dwelling Period and SLR Coping Strategies 179

Table 7.16: Correlation between Occupation and SLR Coping Strategies 180

Table 7.17: Correlation between Education Level and SLR Coping Strategy 181

Table 8.1: Organizational Assistances for Community Based Awareness Program...192
Table 8.2: Major Organizations Provided Assistances for Community based Awareness Creation....193
Table 8.3: Information about Sea Level Rise....194
Table 8.4: Organizational Assistances for Information Regarding Danger of Sea Level Rise....195
Table 8.5: Assistances Provided by Agriculture Extension Worker....197
Table 8.6: Assistance for Fishery, Livestock and Poultry....198
Table 8.7: Foreign Assistance for Climatic Disaster of the Study Area....199
Table 8.8: Satisfaction Level of Inhabitants about Foreign Support....200
Table 8.9: Level of Satisfaction on Provided Service and Information by Different Organizations....201
Table 8.10: Summary of Institutional Assistances for Enhancing Adaptation and Livelihood Security in Study Unions....202
Table 9.1: Number of Months Household had Adequate Food to Feed All Members....210
Table 9.2: Household's Perception about Adequacy of Food Consumption per Day .212
Table 9.3: Household's Anxiety for Future Food Consumption....213
Table 9.4: Measuring Household Food Security Based on Per Capita per Day Calorie Consumption....214
Table 9.5: Defining Criteria of Different Selected Variables for Correlation and Regression Model....215
Table 9.6: Correlation Matrix of Different Variables....216
Table 9.7: Body Mass Index of Reproductive Women between 15-59 Years....221
Table 9.8: Percent Weight for Height for Under Five Years of Children....223
Table 9.9: Weight-for-Age of Under Five Children....224
Table 9.10: Height-for-Age of Under Five Children....225
Table 9.11: Annual Income of the Household by Village, Gender, Education and Livelihood Groups....226
Table 9.12: Annual Income of the Household by Livelihood Groups....227
Table 9.13: Annual Income of the Household by Education Groups....227
Table 9.14: Annual Income of the Household by Gender Groups....228
Table 9.15: Total Expenditure of the Household by Different Study Area....229

Table 9.16: Sources of Household Debt by Village 230
Table 9.17: Household's Amount of Borrowing by Village.......................................231
Table 9.18: Distribution of Households Based on Savings 232
Table 9.19: Distribution of Households Based on Savings category 232
Table 9.20: Number of Living Rooms in Housing Unit 235
Table 9.21: Safety Status of Housing Unit 235
Table 9.22: Electricity Connection in Housing Unit 236
Table 9.23: Types of Sanitation Facility by Union 238
Table 9.24: Distribution of Household by Drinking Water Facility 239
Table 9.25: Distribution of Household by Perception about Arsenic Test of Tube Wells.239
Table 9.26: Distribution of Household based on Immunization of Children by Union 241
Table 9.27: Distribution of Households based on Child Death by Union 242
Table 9.28: Type of Medicare Facilities Enjoyed by Household by Union 243
Table 9.29: Education Status of Respondent 244
Table 9.30: Comparative Aspects of Livelihood Security Indicators in Six Unions 248

Contents of Figures

Figure 1.1: Rising Tendency of Sea Level Rise. 9
Figure 1.2: Projected Inundation of Sea Level Rise in Bangladesh. 12
Figure 1.3: Sustainable Livelihoods Framework of DFID..19
Figure 1.4: Access to Resources to Maintain Livelihoods..20
Figure 1.5: The Household Livelihood Security Model of Sanderson 22
Figure 1.6: Conceptual Framework of Sustainable Adaptation in Bangladesh..............23
Figure 3.1: Selection Procedure of Study Area. 46
Figure 3.2: Location Map of the Study Area in Bangladesh..47
Figure 3.3: Location Map of the Study Area in Bangladesh (Shymnagar Upazila).......48
Figure 3.4: Location Map of the Study Area in Bangladesh (Kalapara Upazila)...........49
Figure 3.5: Location Map of the Study Area in Bangladesh (Cox's Bazar Sadar Upazila) 50
Figure 3.6: Research Design, Data Collection Methods and Analysis 59
Figure 5.1: Projected Inundation Map of Bangladesh Due to Sea Level Rise 79
Figure 5.2: Present Soil Salinity Position of the Study Unions....................................86
Figure 5.3: Present Nutrient Status of Respondents in the Study Unions......................90
Figure 5.4: Causal Loop Diagram of Sea Level Rise Impacts on Coastal Fisheries Sector..94
Figure 5.5: Land Use Pattern of Study Area 96
Figure 5.6: Total Area and Potential Land Loss by 1m SLR 98
Figure 5.7: Soil Texture of the Study Area 99
Figure 5.8: General Soil Type of Study Area...107
Figure 6.1: Livelihood Asset Pentagon by Livelihood Groups..................................138
Figure 6.2: Level of Aggregate Livelihood Capitals Index Value (0-1)......................145
Figure 8.1: Comprehensive Disaster Management Institutional Framework in Bangladesh..187

Contents of Abbreviations

AR4	Fourth Assessment Report
BBS	Bangladesh Bureau of Statistics
BDT	Bangladeshi Taka (Currency of Bangladesh)
BMD	Bangladesh Meteorological Department
CBO	Community Based Organization
CCC	Climate Change Cell
CDMP	Comprehensive Disaster Management Programme.
CEGIS	Centre for Environmental and Geographical Services
GO	Government Organization
GDP	Gross domestic Product
GIS	Geographic Information System
IPCC	Intergovernmental Panel on Climate Change
ICZM	Integrated Coastal Zone Management
NGo	Non-Government Organization
LGED	Local Government Engineering Department
MDG	Millennium Development Goal
MOEF	Ministry of Environment and Forest
NAPA	National Adaptation Programme of Action
SLR	Sea Level Rise
SPSS	Statistical Package for the Social Sciences
UGC	University Grant Commission
UNDP	United Nations Development Programme
UNFPA	United Nations Fund for Population Activities
WB	World Bank

Glossary

Amon	Rice plant transplanted in the monsoon depending on natural rains and harvested in November/ December.
Aus	A variety of rice grown during the summer period mainly rain fed conditions.
Bazar	The daily market
Bigha	Land measurement introduced by the British and used in Bangladesh.
Char	Low-lying river islands
Dadon	Informal rural money lending institution
Disaster	Disaster means a serious disruption to a community.
Gher	Fish enclosure
Hazard	Hazard means an event that has the potential to cause a disaster.
High Yielding Varieties	Varieties of crops that offer higher yield than the natural varieties of the same species.
Kharif	Season for summer crop
Mahajan	A person who provides money for interest.
Mitigation	Mitigation means the process of implementing measures that eliminate or significantly reduce the risks associated with potential hazards.
Natural Disaster	Natural Disaster is a disaster caused by the impact of a natural hazard.
Parishad	Council
Robi	Season for winter crop
Samity	Association of a group of people with some interest
Standing Orders on Disaster	Standing Orders on Disaster means standing orders issued by The National Disaster Management Council under the direction of the Government.
Thana	Local police station
Union	Geographical unit comprising several villages
Upazila	Geo-administrative unit under a district comprising several unions

Chapter One
Background of the Study

1.1 Introduction

Acceleration of Sea level rise as a result of global climate change has become a serious challenge for sustainable management for global coastal zone and it has been considered as a very emerging issue for Bangladesh. Bangladesh is a highly populated disaster prone country with a population of 152 million.[1] The geographical and meteorological characteristics have made the country vulnerable to different hydrological hazards. The major disasters of the country are floods, cyclones, tidal surges, tornadoes, earthquakes, river bank erosion, high arsenic contents of ground water, water logging by sea level rise, water and soil salinity etc. These events turned into disasters when they severely affect the environment including human being's shelters and resources essential for livelihoods. Climate change is gradually increasing the risks for the coastal people of Bangladesh. Bangladesh will be the worst victim of natural calamities because of the event of climate change which causes massive loss of lives and properties.[2]

Globally, Bangladesh is considered as one of the most vulnerable countries to the various impacts of climate change. The country is situated within the tropical zone and the largest delta in the world made by the mighty rivers, the Ganges, the Jamuna and the Meghna. The Himalayan range to the north gives the country a special geographical feature. The Bay of Bengal to the south with its funneling towards Meghna estuary has impact on the southern coastline of Bangladesh. The integrated impacts of the role played by these special geographical features have significant bearing on the coastal zone of the country. For geographic location, dominance of floodplains, low elevation of land from the sea, high density of population, high level of poverty and dependence on nature for its resources and services, the country is highly vulnerable to climate change induced sea level rise.[3]

---

[1] Bangladesh Bureau of Statistics, *Statistical Yearbook of Bangladesh 2011*. 31st ed. Bangladesh Bureau of Statistics, Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh (Dhaka: September 2012).

[2] David Hutton and C. Emdad Haque, "Patterns of Coping and Adaptation among Erosion-Induced Displaces in Bangladesh: Implications for Hazard Analysis and Mitigation," *Natural Hazards* 29, no. 3 (2003): 406.

[3] Anwar Ali, "Climate Change Impacts and Adaptation Assessment in Bangladesh," *Climate Research* 12, no. 2-3 (1999): 110.

The coastal areas especially the offshore islands are the most vulnerable considering the impacts of climate change and variability. The coastal area of the country is different from rest of the country not only for its unique geo-physical characteristics but also for different socio–economic consequences that often leads coastal population to perpetuate risk and vulnerabilities.[4]

Coastal areas include coastal plain islands, tidal flats estuaries, neritic and offshore islands. It extends to the edge of a wide (about 20 km) continental self. A vast river network, a dynamic estuarine system and a drainage basin intersect the coast zone, which make the coastal ecosystem as a potential source of natural resources by the diversified fauna and flora composition, but there are also immense risk of natural disasters. This coastal area represents an area of 47,211 km^2, 32% of the country's geographical areas, wherein 35 million people i.e. 28% of the country's total population live at 6.85 million households.[5] In terms of administrative consideration, 19 districts out of 64 are considered as coastal districts. A study reveals that 20% and 40% of the world population live within 30 kilometer and 100 km of the coast respectively which is very true in regards of Bangladesh.[6]

The present study is concerned with the impact of climate change induced sea level rise that affects the livelihood security of the inhabitants of coastal Bangladesh. The study found how sea level rise affected the livelihood of coastal people in many ways such as crop cultivation, losses and damage of fisheries, poultry, vegetable garden, shortage of pure drinking water, malnutrition, extreme poverty, health problems, etc. which resulted in unemployment of coastal population. As a result, the coastal communities are bound to take several alternative means of livelihoods to cope with the adverse impact of climate change induced sea level rise related disasters. Adaptation, mitigation strategies and action measures are to be taken by the government and policy makers of the country to combat future threats of climate change induced sea level rise. Before taking these types of I nitiatives, it is needed to know the knowledge and concepts, capacity and strength

[4] A. U. Ahmed, "Toward Integrating Adaptation to Climate Change in Current Policy Regime: Perspectives on Bangladesh's Water Resources and Associated Sectors," *Asia Pacific Journal on Environment and Development* 12(2005): 37.

[5] Bangladesh Bureau of Statistics, *Statistical Yearbook of Bangladesh 2011*. 31st ed. Bangladesh Bureau of Statistics, Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh (Dhaka: September 2012), 87.

[6] IPCC, Climate Change 2007: *Synthesis Report*. Intergovernmental panel on climate change. Available at: http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf (Accessed 12 February 2016)

and awareness of coastal population. The study attempted to find out the type of alternative policies regarding livelihood security to be adapted by the people of coastal Bangladesh and it also showed how the coastal people solved their problems through adopting and searching alternative employments.

1.2 Problem Statement

Bangladesh is ranked third as vulnerable countries among the top ten vulnerable countries in the world threatened by sea level rise, because of her geographical position. It is projected that about 20% of the land of Bangladesh will be flooded and covered by the sea as a result of only 1 meter rise in the present water level of the sea by 2100.[7]

According to the statement of International Climate Risk Assessments Bangladesh is a vulnerable country to negative impact of climate change and stays behind the high intensity of natural disasters. The country is highly vulnerable to sea level rise, as it is densely populated costal country of smooth relief comprising broad and narrow ridges and depressions.[8] According to World Bank (2000) analysis it is evident that a large portion of the coastal region will be affected by upcoming event of climate change induced sea level rise. 10 cm, 25 cm and 1 m rise in sea level by 2020, 2050 and 2100 will affect 2%, 4% and 17.5% of total land mass respectively.[9] As a result, the whole of the southern coast of Bangladesh as well as the mangrove systems on Sundarbans will be lost.

Another considerable factor for sea level rise in Bangladesh is subsidence. The Ganges and the Brahmaputra deliver approximately 1.6 billion tons of sediment annually to the face of Bangladesh.[10] These sediments compensate the natural compaction and subsidence of delta and keep its size stable, relatively. So, sediment replacement is considered to balance subsidence of delta that results a net sea level rise.[11]

---

[7] IPCC, Climate Change 2007: *Synthesis Report*. Intergovernmental panel on climate change. Available at: http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf (Accessed 12 February 2016).

[8] H. Brammer, *The Physical Geography of Bangladesh* (Dhaka: The University Press Limited, 2012), 547.

[9] Md Golam Mahabub Sarwar, "Impacts of Sea Level Rise on the Coastal Zone of Bangladesh," available at *http://static weadapt. Org/placemarks/files/225/golam_sarwar. Pdf* (2005) (Accessed 12 March 2016).

[10] J. M. Broactus, "Possible Impacts of, And Adjustments to, Sea Level Rise: The Cases Of Bangladesh And Egypt," *Climate and Sea Level Change: Observations, Projections, and Implications* 5 (1993): 263.

[11] Shardul Agrawala, Tomoko Ota, Ahsan Uddin Ahmed, Joel Smith and Maarten Van Aalst, "Development and Climate Change in Bangladesh: Focus on Coastal Flooding and the Sundarbans," *OECOD, France* (2003): 35.

A study by SAARC Meteorology Research Centre found that tidal level in Hiron point, Char Changa and Cox's Bazar raised 4.0 mm/year, 6.0 mm/year and 7.8 mm/year respectively, by observing tidal gauge record of the period 1977-1998.[12] The rate of tidal trend is almost double in the eastern coast than that of the western coast. Saline water intrusion is the biggest threat which comes from sea level rise into the river of southern coast line. It is reported that 0.5 cm per year sea level rise happens in Bangladesh. Another report showed 1.5 m sea level rise in Bangladesh coast by 2030 affecting 22000 Sq. Km. (16% of total landmass) area which will affect 17 million (15% of total population) population.[13] This could lead to a decrease of the agricultural production and impede the achievement of GDP.

Along the Bay of Bengal Bangladesh has a Coast line of 710 kilometers. As defined by criteria including the reach of tidal waters, salinity intrusion, and the landward influence of cyclones and storm surges, fully one-third of the country is categorized as belonging to the coastal zone. The outer boundary of the exclusive Economic Zone delimits the seaward coastal zone. The coast of Bangladesh constitutes a region of both vulnerabilities and opportunities. It possesses a great diversity of natural resources including coastal fisheries, forests, salts and minerals, as well as high potential for exploitation of both onshore and offshore natural gas. It also offers sites for harbors, airports, tourism facilities, and development opportunities. Increasing population, competition for limited resources, natural and anthropogenic hazards, lack of economic opportunities in some areas need proper coastal management strategies.[14] The government of Bangladesh realizes that climate change poses a serious threat for development and acknowledges the need to project coastal ecosystems and optimize the utilization of coastal resources as the state's Poverty Reduction strategy Paper also recognizes the risks of sea level rise. The Government of Bangladesh (GoB) has detected coastal zone is vulnerable to adverse impacts of climate change induced sea level rise.[15]

---

[12] M. S. Alam and K. Uddin, (2013) "A Study of Morphological Changes in the Coastal Areas and Offshore Islands of Bangladesh Using Remote Sensing," *American Journal of Geographic Information System 2*, no1 (2013): 15.

[13] John D. Milliman, James M. Broadus and Frank Gable, "Environmental and Economic Implications of Rising Sea Level and Subsiding Deltas: The Nile and Bengal Examples," *Ambio* (1989): 341.

[14] Robert J. Barro and Jong-Wha Lee, "IMF Programs: Who is Chosen and What Are the Effects?" *Journal of Monetary Economics* 52, no. 7 (2005): 1246.

[15] Q. K. Ahmad and Ahsan Uddin Ahmed, "Regional Cooperation in Flood Management in the Ganges-Brahmaputra-Meghna Region: Bangladesh Perspective," In *Flood Problem and Management in South Asia*, Springer Netherlands, (2003):182.

The densely populated coastal zone with port and major tourism facilities are located within the southern coastline. Increase of wave action by sea level rise contributes to the erosion along the southern part of coastline. This has led to loss of important sites, infrastructure as well as coastal flora and fauna.[16] Moreover, sea level rise would have a serious impact on agricultural production in coastal lowland since its resilience depends heavily on strategic approaches to water management capable of addressing climate change impacts on future renewal rates on ground water resources, flow and salinity of rivers.[17] Salt water intrusion has already destroyed many farmlands making a large number of farming households poorer.

Climate change induced sea level rise has a great influence on livelihoods of coastal region population, especially the livelihoods that mostly natural resource oriented. Bangladesh, like many other developing countries, coastal traditional livelihoods are very much dependent on agriculture. Crops production and fisheries are largely affected by intrusion of saline water.[18] Therefore, sustainable livelihoods rely on sustainable management of our ecosystem. The poor of coastal area of the country depend directly on natural resources, through cultivation, herding, collecting or hunting for their livelihoods. Therefore, for the livelihoods to be sustainable, the natural resources must be sustained.

Sea level rise will displace millions of poor people from vulnerable coastline of the world, including Bangladesh. It is expected that these displaced people will have few opportunities to reestablish their previous livelihoods and naturally they will try to fit in the urban areas where they will obviously find themselves in limited livelihoods opportunities. Even where people will not be physically displaced, sea level rise will reduce their social capital in ecosystem such as coastal fisheries, mangroves and wetlands that are essential to the current livelihoods patterns of many poor communities, while the danger of water supplies will affect these and other coastal communities.[19]

---

[16] M. S. Islam, "Perspectives of the Coastal and Marine Fisheries of the Bay of Bengal, Bangladesh," *Ocean & Coastal Management 46,* no. 8 (2003), 765.

[17] J. M. Broactus, "Possible Impacts of, and Adjustments to, Sea Level Rise: The Cases of Bangladesh and Egypt," 268.

[18] Z. Karim, S. G. Hussain and M. Ahmed, "Assessing Impacts of Climate Variationson Food grain Production in Bangladesh," *Water, Air, and Soil Pollution* 92(1996): 55.

[19] Bishawjit Mallick, Sebastian Marcel Witte, Raju Sarkar, Apurba Swatee Mahboob and Joachim Vogt, "Local Adaptation Strategies of a Coastal Community During Cyclone Sidr and their Vulnerability Analysis for Sustainable Disaster Mitigation Planning in Bangladesh," *Journal of Bangladesh Institute of Planners* 2 (2009): 159.

Over the recent years, it is observed that climate change induced sea level rise has become an important issue and it is clear that to meet the challenges of it there should be specific strategic actions. Climate change increases sensitivity and frequency of disasters with adverse impact on human, natural ecosystem and quality of human services. A densely populated country like Bangladesh is widely considered as a vulnerable country due to her terrestrial location. Sea level rise due to climate change is the atrocious type of vulnerability. High level of poverty and exhaustive ecosystem intensify the negative impacts of sea level rise.[20] Projection made by IPCC regarding climate change it reveals that south Asian countries will be the most vulnerable due to sea level rise as 22% of world population live here who directly depend on agriculture. All these incidents make Bangladesh most vulnerable by sea level rise.[21]

Climate change induced sea level rise will also affect ecosystem and bio diversity of the coastal region of Bangladesh. Intrusion of saline water to the drinkable water source will cause serious threat to the lives of the species living in the coastal belt. Its impact also makes the world's greatest mangrove forest Sundarbans vulnerable. The scenario is gradually intensifying the disaster and composing the risks to the coastal people in Bangladesh.

1.3 Operational Definition of the Key Terms

Climate Change: Climate change is any change in climate over time, whether due to natural variability or as a result of human activity. It is statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural processes or external forcing, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.[22]

Livelihood: Livelihoods are described as an array of assets arrangements approaches of production, consumptions, and exchange for enhancing human living conditions.[23]

---

[20] Yusuf Sharif Ahmed Khan and M. Sahadat Hossain, "Impact of Shrimp Culture on the Coastal Environment of Bangladesh," *International Journal of Ecology and Environmental Sciences* 22, no. 2 (1996): 146.

[21] Osvaldo F. Canziani, Jean P. Palutikof, Paul J. van der Linden and Clair E. Hanson, *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Edited by Martin Parry. Vol. 4. (Cambridge: Cambridge University Press, 2007), 469.

[22] David J. Griggs and Maria Noguer, "Climate Change 2001: The Scientific Basis. Contribution of Working Group I To The Third Assessment Report of The Intergovernmental Panel on Climate Change," *Weather* 57, no. 8 (2002): 267

[23] Anwar Ali, "Climate Change Impacts and Adaptation Assessment in Bangladesh," *Climate Research* 12, no. 2-3 (1999): 110.

Risk: A probability or threat of damage, injury, liability, loss or any other negative occurrence that is caused by external or internal vulnerabilities, and that may be avoided through preemptive action.

Vulnerability: Vulnerability is a measure of the degree to which a human or natural system is unable to cope with adverse effects. It is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. In other words, vulnerability is a set of conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of a community to the impact of hazards.[24]

Resilience: Resilience is the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change.[25]

Adaptation: Adaptation is the adjustment that society or ecosystems make to limit negative effects of climate change. It can also include taking advantage of opportunities that a changing climate provides.[26]

Mitigation**:** Mitigation means reducing risk of loss from the occurrence of any undesirable event.

Coastal Zone of Bangladesh: The coastal zone of Bangladesh consists of 19 administrative districts. 12 districts of them are defined as exposed coast and the rest 7 districts are defined as interior coast (The districts are Bagerhat, Barguna, Barisal, Bhola, Chandpur, Chittagong, Cox's Bazar, Feni, Gopalganj, Jessore, Jhalkati, Khulna, Lakshmipur, Narail, Noakhali, Patuakhali, Pirojpur, Satkhira and Shariatpur). About 32% of the land area of the country and 28% of total population of the country live in this coastal zone.[27] More than 3.5

---

[24] IPCC, Climate Change 2007: *Synthesis Report.* Intergovernmental panel on climate change. Available at: http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf (Accessed 12 February 2016).

[25] J. Oerlemans, " Effect of Irregular Fluctuation in Antarctic Precipitation on Global Sea Level," *Nature* 290(1981): 770

[26] A. U. Ahmed, "Toward Integrating Adaptation to Climate Change in Current Policy Regime: Perspectives on Bangladesh's Water Resources and Associated Sectors," *Asia Pacific Journal on Environment and Development*. Vol. 12, No.1 (2005): 37.

[27] Bangladesh Bureau of Statistics, *Statistical Yearbook of Bangladesh 2011*. 31st ed. Bangladesh Bureau of Statistics, Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh (Dhaka: September 2012).

crore of people of the country depend on this coastal zone for their livelihoods. The people of the zone depends on mangrove forests of Sundarbans, shrimp farms, fisheries, agriculture, deposits of mineral salts etc. for their livelihoods.

1.4 Present Scenario of Sea Level Rise (SLR)

Climate change has direct impact on rising sea level. The global environment as well as Bangladesh being a low lying country would be affected massively by the rise in sea level. The scenarios of sea level rise are presented in the following sections.

1.4.1 Climate Change and Sea Level Rise

Climate change has become a global issue. It refers to the statistically significant change in the measurements of either the mean state or variability of the climate for a place or region over an extended period of time due to the impact of human action on the composition of the global atmosphere or due to natural variability either directly or indirectly.[28] Sea level rise is mainly caused by climate change with a number of factors including thermal expansion of the ocean, the melting of the Greenland and Antarctic ice caps, and inflows in to the seas from melting glaciers on land. As increased radioactive force causes the atmosphere to warm, the ocean absorbs more than 80% of the heat added to the climate system, causing the water to expand. This thermal expansion accounted for between 0.30 and 0.54 mm in average sea level rise between 1961 and 2003. Melting of glaciers and ice caps accounts for the highest contribution to sea level rise - an estimated 0.32 to 0.68 mm/year.[29] A scenario of GW (Global Warming) and SLR (Sea level Rise) has been projected by Warrick et al., 1996 is given below-

Table 1.1: Global Warming (GW) and Sea Level Rise (SLR) Scenario

Model Assumption	GW Scenario by year (^{0}C)				SLR Scenario by year (cm)			
	2010	*2030*	*2050*	*2100*	*2010*	*2030*	*2050*	*2100*
Low	0.3	0.7	1.2	2.2	4	8	15	31
Business-as-usual	0.5	1.1	1.7	3.3	8	18	30	66
High	0.7	1.5	2.5	4.9	13	29	48	110

Source: (Warrick et al., 1996)[30]

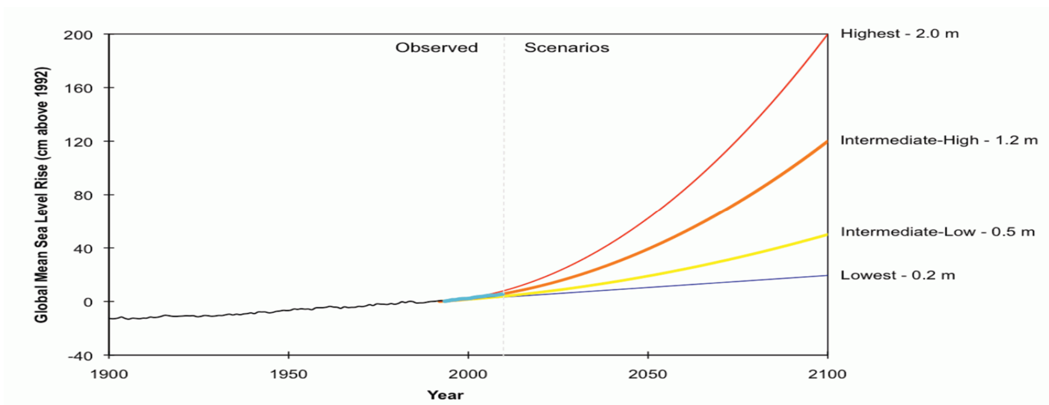
[28] J.G. Titus, R.A. Park, Leatherman, S.P. Weggel, S.P. J.R. Greene, M.S. Mausel, P.W., Brown, S. Gaunt and G. Trehan, "Greenhouse Effect and Sea Level Rise: The Cost of Holding Back the Sea." *Coastal Management 19*(1991), 172.

[29] Peter Lemke, Jiawen Ren, Richard B. Alley, Ian Allison, Jorge Carrasco, Gregory Flato, Yoshiyuki Fujii et al., "Observations: Changes in Snow, Ice and Frozen Ground," (2007) available at https://www.ipcc.ch/ publications_and_data/ar4/wg1/en/ch4s4-4.html (accessed 2 March 2016).

[30] R. A. Warrick, G. J. Kenny, G. C. Sims, N. J. Ericksen, Q. K. Ahmad, and M. Q. Mirza. "Integrated Model Systems for National Assessments of the Effects of Climate Change: Applications In New Zealand And Bangladesh." In *Climate Change Vulnerability and Adaptation in Asia and the Pacific* (Springer, Netherlands) (1996): 221.

Other factors such as, land subsidence, can affect the sea level rise occurring in particular locations. For example the north Indian Ocean sea level shows a linear increasing trend of 0.31 mm/year due to land subsidence between1958 and 2000. One recent report has found a trend of increasing sea level rise Hiron point near Sundarbans of 5.3 mm/year between 1977 and 2002; some of the other stations along the Bangladesh coastline also show increasing trends of sea level rise.[31] In 2007, the intergovernmental panel on climate change (IPCC) estimated that 0.6 meters or more global sea level will rise due to climate change which will top 1 meter or more by 2100. The most recent sources indicate that the current global mean sea level rise has reached 3.1 mm/year.

Figure 1.1: Rising Tendency of Sea Level Rise.



Source: IPCC 2007, http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf accessed 12 February 2016.

Ericson et al. made an assessment of contemporary effective sea level rise (ESLR) of 40 deltas across the world. The estimated ESLR ranged from 0.5 to 12.5 mm/year with the three highest ESLR were for densely populated and agriculturally active deltas in south Asia including Bangladesh and India. Based on assessment made by Ericson et al. 2006, the mean ESLR from Asia, North America, Africa, South America, Europe, Africa and Oceanic were 4.6, 4.5, 4.4, 3.5, 2.6, and 1.0 mm/year respectively (i.e. highest ESLR from Asia and lowest from Oceania).[32] Internationally there are some reports of sea level rise from different sources for planning purposes, which is presented below

[31] G. M. Sarwar and M. H. Khan, "Sea Level Rise: A Threat to the Coast of Bangladesh," *Internationales Asien forum*, No. 3–4, Vol. 38(2007): 377

[32] J. P. Ericson, C. J. Vörösmarty, S. L. Dingman, Ward, L. G. Ward and M. Meybeck, "Effective sea-level rise and deltas: causes of change and human dimension implications," *Global and Planetary Change 50*, no. 1(2006): 65.

Table 1.2: Summary of International Sea Level Rise Values for Planning Purposes

Source	Report	Estimate of global mean rise by 2100
University of New South Wales Climate Change Research Centre	"The Copenhagen Diagnosis"	Up to 2 m
Department for Environment, Food and Rural Affairs (DEFRA)	"UK Climate Projections"	0.3-0.5 m, high scenario of 1.9 m
International Alliance of Research Universities (IARU)	"Synthesis Report from Climate Change, Global Risks, Challenges & Decisions" (2009)	0.5-1.5 m
California	"The Impacts of Sea-Level Rise on the California Coast"	1.0-1.4 m
United Nations Environment Programme (UNEP)	"Climate Change Science Compendium"	0.5-1.4 m
Delta commissie, Denmark	"Working together with water"	0.65-1.3 m
Department of Climate Change, Australia	"Climate Change Risks to Australia's Coast"	1.1 m

Source: Royal Society of NZ. *Sea Level Rise: Emerging Issues*. Emerging Issues paper produced by Royal Society of New Zealand, September 2010 available at *www.slideshare.net/sea-level-rise-emerging-issues-paper-royal-society-of-new-zeal* (accessed 02 January 2017).

1.4.2 Impact of Climate Change Induced Sea Level Rise on Bangladesh

Climate change and sea level rise are now a reality. The recent finding of the fourth assessment report of the world scientific community, represented by the Inter panel governmental on climate change (IPCC), demonstrates that human activities are responsible for global warming and global climate change and sea level rise. Various human activities are making the world hot to hotter where the ultimate result is global warming which promotes climate change.[33] Anthropogenic causes responsible for global warming are expected to continue to contribute an increase in global–mean sea level rise during this century and beyond.[34] It is commonly accepted that the global average surface air temperatures have risen by 0.74°c (0.56°c to 0.92°c) over the last 100 year from 1906 to 2005. Rising temperature in the atmosphere causes sea level rise and affects low lying coastal area and deltas of the world. The major environmental effects of sea level rise include the loss of habitats and biodiversity due to inundation, shoreline retreat, increased coastal flooding, land slide and erosion during storm surges and rain storms, and the intrusion of salt water into aquifers, estuaries, and wetlands. Sea level rise will increase

[33] A. Rahman, *Beel Dakatia: The Environmental Consequences of a Development Disaster* (Dhaka: University Press, 1995), 15.

[34] IPCC, *Assessment-report,* available at http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf (Accessed 10 February 2016),

the vulnerability of coastal population and ecosystem via permanent inundation of low-lying region, inland extension of periodic flooding, increased beach erosion and salinity intrusion of aquifers.[35]

Bangladesh's geophysical vulnerability lies in the fact that it is an exceedingly flat low lying, alluvial plain covered by over 230 rivers and rivulets with approximately 710 kilometers of exposed coastline along the Bay of Bengal. As a result of its geography, Bangladesh frequently suffers from devastating floods, cyclones and storm surge, tornadoes, river bank erosion as well as constituting a very high risk location to climate change induced sea level rise.[36] Ahmed and Alam found that the average increase in temperature in Bangladesh would be 1.3°c and 2.6°c by the year 2030 and 2075 respectively with respect to the base year 1990.[37] Two estimate of potential future sea level rise in Bangladesh are 0.30-1.5 m and 0.30-0.50 m for 2050. Analysis of meteorological data from 1977 to 1998 clearly shows annual sea level rise at Hiorn point in Sundarbans was 4 mm/year.[38] Sea level rise has various impacts on Bangladesh like river bank erosion, salinity intrusion, flood, damage to infrastructures, crop failure, destruction of fisheries, loss of biodiversity etc. Its potential threats are coming strongly in the future.

Table 1.2: Sea Level Rise (SLR) Scenarios in Bangladesh and Its Possible Impacts

Impact on	Projected		
	2020	2050	2100
Sea Level Rise	10 cm	25 cm	1 m (high end estimate)
Land below SLR	2%	4%	17.5%
Storm surge	-	Storms surge goes from 7.1 to 8.6 m with 0.3 m SLR.	Storms surge goes from 7.4 to 9.1 m with 0.3 m SLR.
Flooding	20% increase in inundation	Increase flooding in Meghna and Ganga floodplain.	Both inundation area and flood intensity will increase tremendously
Agriculture	Inundate 0.2 million metric tons of production; <1% of current total	0.3m SLR inundates 0.5 Mmt. of production; 2% of current total.	Devastating flood may cause crop failure for any year.
Ecosystem	Inundates 15% of the Sundarbans.	Inundates 40% of the Sundarbans.	The entire Sundarbans would be lost.
Salinity	increase	increase	increase

Source: World Bank 2000 available at https://germanwatch.org/download/klak/fb-ms-e.pdf accessed 11 November 2016.

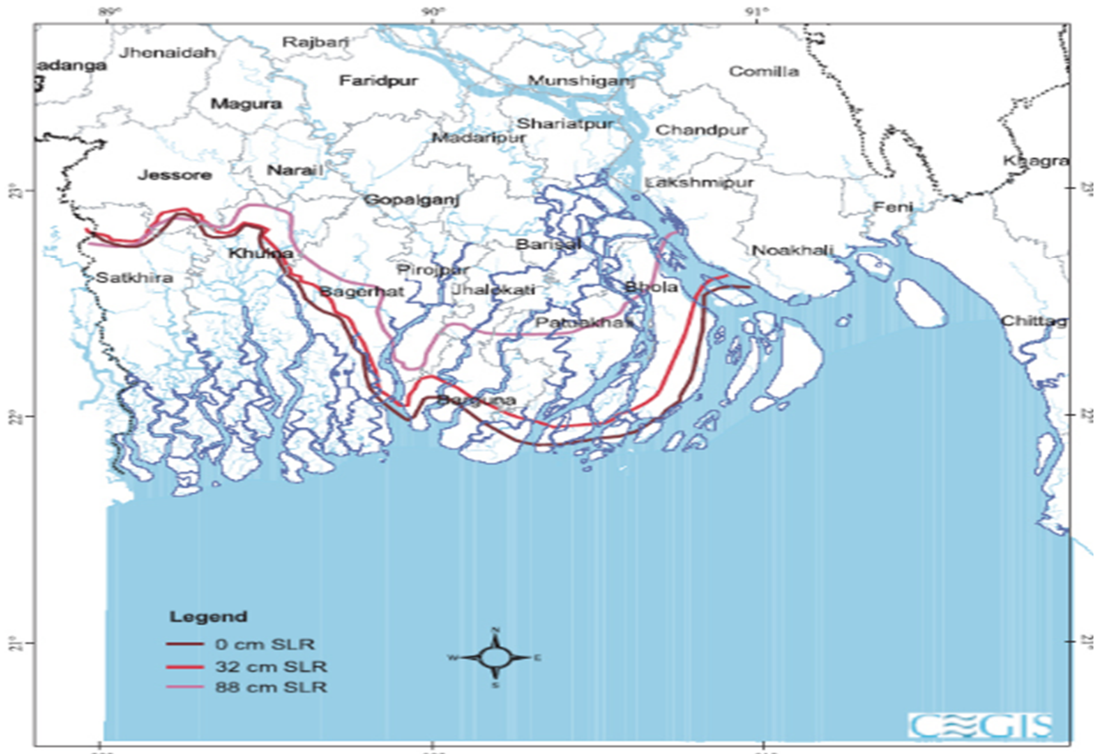
[35] G. M. Sarwar and M. H. Khan, "Sea Level Rise: A Threat to the Coast of Bangladesh," *Internationales Asien forum*, No. 3–4, Vol. 38(2007): 380

[36] Ibid., 382.

[37] A. U. Ahmed and M. Alam, *Vulnerability and Adaptation to Climate Change for Bangladesh* (Netherlands: Springer, 1998), 13.

[38] Md. Shamsuddoha and Rezaul Karim Chowdhury, "Climate Change Impact and Disaster Vulnerabilities in the Coastal Areas of Bangladesh," (*Dhaka: COAST Trust,* 2007), 10.

Figure 1.2: Projected Inundation of Sea Level Rise in Bangladesh.



Source: Adopted from *CEGIS,* available at http:// *www.cegisbd.com/projects.aspx* (accessed 05 January 2017).

1.5 Research Gap

A number of studies regarding climate change induced sea level rise and its effect on the environment of the coastal zone have been done but so far we know the study about the impact on livelihood security of coastal zone population of Bangladesh have not been carried out. Though some studies have been done regarding sea level rise and its impact on the environment but the nature of coastal zone, soil, climate, topography, socio-economic conditions of the inhabitants of coastal zone of Bangladesh are totally different from these countries and they are different from each other as the position of country, sample size, time range, and other variables. Bangladesh is a low-lying delta, so coastal zone is highly vulnerable to the impact of sea level rise. Economy of Bangladesh is agriculture dependent which is also the basic source of income of coastal people. Moreover, coastal zone of the country is densely populated and huge number of population live in the coastal zone. Hence, it has become a crying need to conduct a comprehensive study to find out the impact of climate change induced sea level rise on livelihood security in Bangladesh.

1.6 Research Questions

By going through the relevant literature, it was found that the issue of climate change induced sea level rise in relation to livelihood security of coastal Bangladesh had huge impact on the whole country. To deal with the issue, the researcher raised some relevant research questions which are shown below:

i. What is the present status of livelihood assets of coastal population in Bangladesh?

ii. What are the possible threats of sea level rise on livelihood security of coastal population of Bangladesh?

iii. What will be the mitigation and adaptation strategies to combat the impact of sea level rise induced vulnerabilities?

iv. What should be the response of the institutional mechanisms to sea level rise?

v. What will be the guidelines for Bangladesh to cope up with the upcoming events of SLR?

1.7 Objectives of the Study

The overall objective of this study is to find out the impacts of climate change induced sea level rise on livelihood security of the coastal population of Bangladesh.

In order to achieve the overall objective, the following specific objectives were pursued

i. to identify the present livelihood assets status of coastal population of Bangladesh;

ii. to identify the potential threats of climate change induced sea level rise on population and coastal environment in Bangladesh;

iii. to find out the mitigation measures and adaptation strategies with a view to cope with the situation of climate change induced sea-level rise in the coastal region.

iv. to assess the livelihood security of coastal communities and underlying factors that influence livelihood security.

v. to formulate guidelines to enhance the resiliency of coastal people against SLR to achieve long term livelihood security.

1.8 Justification of the Study

Bangladesh is vulnerable to climate change and the coastal zone is the worst victim of the consequence of climate change. The country is also one of the victims of degraded

Environment. Sea level rise is the catastrophic consequence of climate change and the result of sea level rise is that a significant part of the country may go under saline water which will displace huge number of coastal people. Moreover it may have adverse impacts on the livelihoods of the coastal population which will make them more helpless.[39]

It has been proved globally by the experts and researchers that climate change will have adverse impacts on the poor and weak developing countries. According to the IPCC observation that there are many reasons behind climate change and the main is global warming. Human activities, burning of fossil fuels, deforestation etc. are the main factors to accelerate atmospheric temperature. These causes have increased the amount of greenhouse gas in the atmosphere. Increased atmospheric temperature prop up sea level rise.[40]

Bangladesh is the world's most densely populated country. It is also one of the most vulnerable regions due to its geographical and spatial location. With a population of over 158 million people in a small area and a population density of more than 1,209 persons per sq.km, and 75% of the population lives in rural areas, it is evident that very densely populated coastal area of the country is vulnerable to sea level rise.[41] Higher population density increases vulnerability to climate change because more people are exposed to risk and opportunities for migration within a country are limited. The country is composed largely of low lying areas and most part of lands remains not above sea level, moreover about 80% land is floodplain. It is also frequently visited by extreme climatic events, causing damage to life, property and economy. The country experiences different kinds of disasters such as tropical cyclones, storm surges, coastal erosion, and floods etc. which jeopardize the development activities. Bangladesh, one of the least developed countries in the world, may also be one of the most vulnerable to climate change induced sea level rise. The predicted sea level rise may experience a number of impacts like inundation of coastal areas, increase likelihood of flooding in storm surge, erosion of coastline etc. These impacts will be enough to affect the livelihood security adversely of the coastal population. Sea level rise is inevitable and it devastates the nation resulting in the loss of land and displacement of many people. Salinity intrusion is a major problem especially

---

[39] Md. Shamsuddoha and Rezaul Karim Chowdhury, "Climate Change Impact and Disaster Vulnerabilities in the Coastal Areas of Bangladesh," (*Dhaka: COAST Trust,* 2007), 10.

[40] Mahbuba Nasreen, *Impact of Climate Change on Agriculture and Food Security* (Bangladesh: Action Aid International and Action Aid Bangladesh, 2008), 13.

[41] World Bank, available at *www.worldbank.org/2013/warming-climate-to-hit-bangladesh-hard-with-sea-lev (*accessed on 25 March 2016)

for the southern coastline of Bangladesh; as a result, major portion of agricultural land will be affected by various degree of soil salinity. So, sea level rise would have serious impact on agricultural production where the population mostly depends on agriculture. So, it is clear that sea level rise has impacts on livelihoods security including health, housing, income, food etc. The present study is aimed to give details about coastal people's vulnerable livelihood caused by climate change induced sea level rise. The study is also designed to find out the nature of alternative livelihood options that minimize individual's vulnerability regarding sea level rise which will also help to reduce the related risks of coastal population. This study will contribute in understanding of the different coping mechanism in providing alternative sources of livelihood which will help coastal people to mitigate the upcoming distress of SLR. It will also provide the basic information about the existing constraints of coastal belt population face regarding SLR. The decision makers can get information from this to make an alternative mechanism of livelihood. This study has analyze what type of support to be provided by the government so that coastal community can escape themselves from this fragile situation. Besides these, institutions or individuals who are interested to know about threatened livelihood of coastal area can use the document of the study as a reference. The possibility of changes in climate and sea-level rise must be considered seriously in the context of the future development of Bangladesh, so conducting research on the proposed title is significant.

1.9 Scope of the Study

This study analyzed and compared sea level rise impacts on the livelihood security of selected coastal zone population of Bangladesh, on the basis of available secondary sources and primary data. The resources includes books, government reports, international reports, scientific journals, maps and news articles that highlighted sea level rise related issues on livelihoods in Bangladesh. Some studies of the same field in other parts of the globe were also considered as source for the study. All the relevant information collected from the vulnerable coastal zone of Bangladesh were analyzed with proper statistical formula. The study attempted to seek for both qualitative and quantitative impacts and also tries to find out some solutions that would help Bangladesh to adapt to the problems of sea level rise. In the study, emphasis was placed on assessing the impacts rather than measuring the rate and cause of sea level rise. The study assessed the actual impact on livelihood scenarios of the coastal belt population who are the vulnerable group of climate change induced sea level rise.

1.10 Limitation of the Study

The coastal zone of Bangladesh lies within the tropical zone between 21-23° N and 89-93° E. The coast can be broadly divided into three regions: the deltaic eastern region, the deltaic central region, and the stable deltaic western region. Coastal districts of the country are being affected directly or indirectly by the influence of tidal waters, salinity intrusion, storm surges etc. The districts are considered including all upazilas. A total of 48 upazilas are considered as 'exposed' directly to vulnerabilities from climate change induced sea level rise. Considering the mentioned matter the study has some limitations due to time and other logistic support constraints. The researcher stayed in the field for a limited time and missed observing the seasonal variations of impacts of SLR. Six representative unions of three upazillas of three districts have been taken as the study area of the research. Though the study area is small portion of coastal zone of Bangladesh but these three upazillas are in the major three important regions of the coastal zone of Bangladesh which represent the vulnerable coastal zone of the country.

1.11 Theoretical Approaches and Conceptual Framework

A number of theories and models have been developed on climate change induced sea level rise issue such as Dynamic Interactive vulnerability Assessment (DIVA), Sea level rise affecting Marshes Model (SLAMM), Climate Change vulnerability issue (CCVI), DFID approaches of sustainable livelihood etc.

The DIVA model is an integrated, global model of coastal system that assesses bio physical and socio-economic consequences of sea level rise and socio-economic development taking into account the following impacts: coastal erosion (both direct and indirect), coastal flooding (including rivers), wetland change and salinity intrusion into deltas and estuaries. It also enables users to take in consideration within the assessment adaptation in terms of raising dikes and nourishing beaches. It also considers impact due to extreme water levels caused by sea level rise over the 21st century at global and regional level. It allows the users to insert future sea level rise scenarios to project future impacts of global scale.

The model comprises four major components as a detail data base with bio physical and socio economic coastal data, global regionalized climate and socio economic scenarios until the year 2050, an integrated model enabling the interaction between modules that assess bio physical and socio economic impacts and the potential effects and costs adaptation and a graphical user interface for selecting data and scenarios, running model simulations and analyze the results. The advantages of DIVA is that it is very much useful for coastal vulnerability assessment, it also enables users to address various key impacts and possible pre defined adaptation strategies and it has already been used international level.[42]

The concept described in the DIVA model is the best fitted in the context of the coast of Bangladesh. The coastal region is already under the threats of erosion, salinity, flooding etc. Adaptation and mitigation measures can be taken according to the model.

Sea level rise Affecting Marshes Model (SLAMM) is a mathematical model that uses digital elevation data and other information to simulate potential impacts of long term Sea level rise on wetland and shorelines. The features of the SLAMM indicate the following characteristics like to address various wetland scenarios, including inundation erosion, over wash, saturation and salinity, compute relative sea - level change for time sequence of 5 to 25 years, incorporate areas protected by dikes and other hard structures if needed, incorporate sedimentation and accretion rates and provide option for computing erosion, incorporate standard coastal wetland classes, provide outputs that can be viewed in a Geographic information system(GIS) or other software for additional analysis. According to the model, it is easy to evaluate all potential threats of the coast of Bangladesh. Proper management for the coast as well as the livelihood security of the inhabitants can be sustained by the guidelines and process of the model.

In CCVI model there are three sets of factors associated with climate change sensitivity like indirect exposure to climate change, species-specific factors relating to sensitivity and adaptive capacity and documented response to climate change.

CCVI tool is used to develop adaptation strategies for the relevant species using different methods. It is a type of model to assess the relative vulnerability of plants and animals species to effects of climate change using readily available about climate projection and species natural history, distribution and landscape circumstances. Relative vulnerability

[42] Jochen Hinkel and Richard JT Klein, "Integrating Knowledge to Assess Coastal Vulnerability to Sea-Level Rise: The Development of the DIVA Tool," *Global Environmental Change* 19, no. 3 (2009): 387.

of the coast of Bangladesh can be assessed by CCVI model to take proper steps for sustainable management of the coast.

Sustainable livelihood approach has been explained by different development authority. The British Department for International Development (DFID) has developed a livelihood approach Framework which is one of the most widely used livelihhod framework in Development practice.

The framework sets out to conceptualise how people operate within a vulnerability context that is shaped by different factors as shifting seasonal constraints or opportunities, economic shocks etc. It also sets out to conceptualize how different types of livelihood assets are influenced by the vunerabilty context, a range of institutions and processes. It also describes how people use their assets to develop a range of livelihood srategies to achieve expected livelihood outcomes .[43] In different hazards the population of the coast of Bangladesh how manage the various livelihood assets has been analysed in this model.

It is an integrated framework which includes vulnerability, access to assets or capitals, livelihood outcomes and recovery. The DFID framework emphasizes on the range of assets (i.e. natural, physical, human, financial and social), access to these assets that make livelihood (in) secure. The framework puts people on the centre of development and aims to assist stakeholders with different point of view to employ in structured and coherent debate about various factors; their relative significance and the way of interaction that affect livelihood. The major elements of the framework include vulnerability context, livelihood assets, transformation structure and process, livelihood strategies and livelihood outcomes.[44] The assets that are discussed in sustainable livelihood framework are sum up by following ways:

Physical Capital: primary infrastructure such as sanitation, energy, transport, communications, housing and production equipment.

[43] Jochen Hinkel and Richard JT Klein, "Integrating Knowledge to Assess Coastal Vulnerability to Sea-Level Rise: The Development of the DIVA Tool," *Global Environmental Change* 19, no. 3 (2009): 384.

[44] DFID: 2000, *Partnership with the Private Sector, Department for International Development*, available at www.dfid.gov.uk/public/working/buspart/ (Accessed 10 February 2016).

Natural Capital: natural resources such as land, water, wildlife, biodiversity and environmental resources.

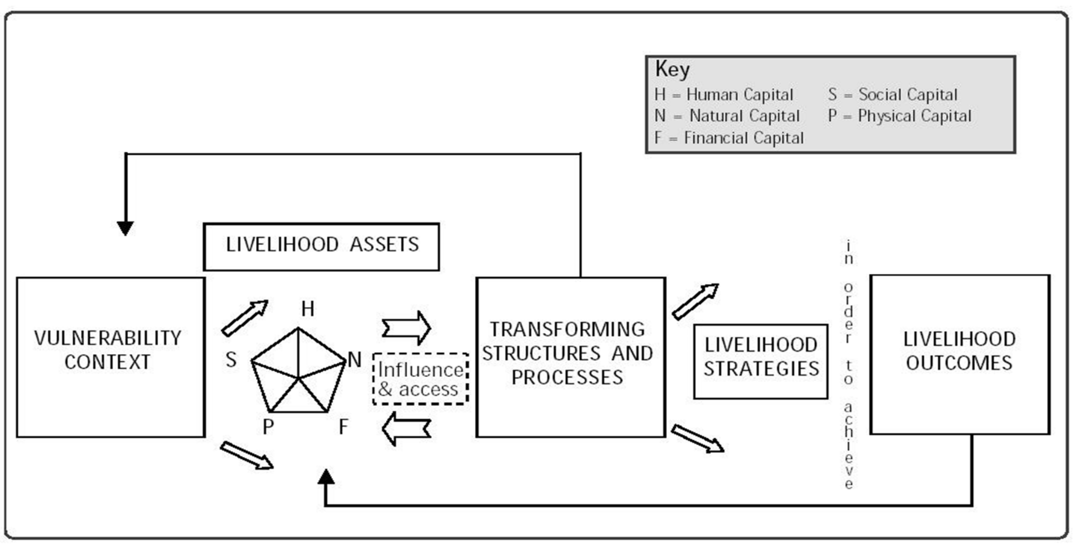
Financial Capital: financial resources such as usual remittances or pensions, savings, supplies of credit etc.

Human Capital: human resources such as knowledge, skill, health, ability to labor.

Social Capital: social resources such as relationships through trust, membership of groups, networks, access to institutions and information.

Apart from five capitals (assets) that underpin in sustainable livelihood framework, McLeod also proposes two more additional assets for example institutional knowledge and institutional or political capital.[45]

Figure 1.3: Sustainable Livelihoods Framework of DFID



Source: Adopted from DFID 2000

Moreover, models of livelihood security by which the vulnerable communities can make them resilient are described below

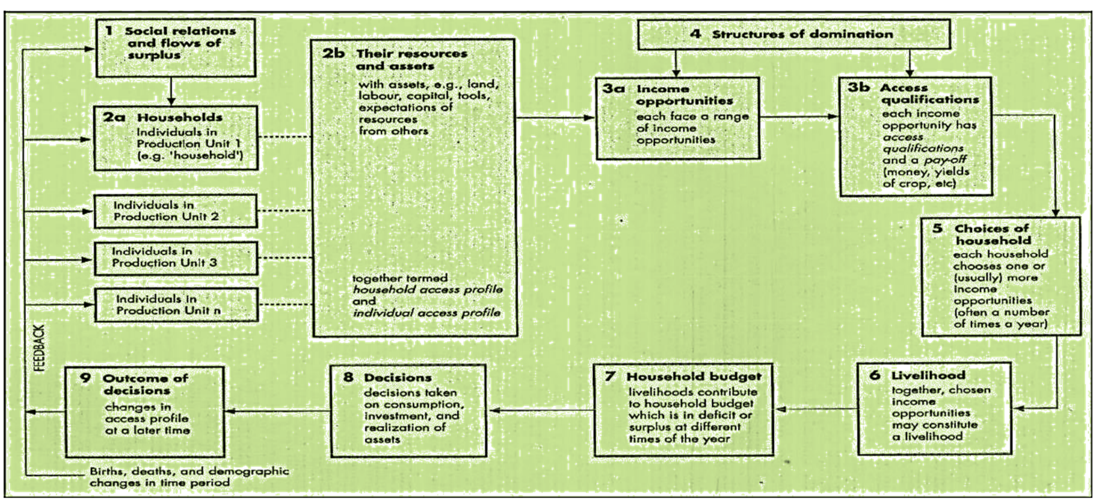
---

[45] Ruth McLeod, *The Impact of Regulations and Procedures on the Livelihoods and Asset Base of the Urban* Poor–*A Financial Perspective*. Working paper, Homeless International, Coventry, 2001.

Access to Resources Model

Access to Resources Model is a dynamic model. In this model it is explained how social, economic and political system creates unsafe conditions for people. Besides, hazards have differential impact on different societies as well as various groups with in a society. The model consider livelihood strategies as key factors to know how individual or household behave to cope with hazard.[46] Access to resources entails the capability of an individual, family, class or community to utilize resources to ensure their livelihood security. This access is almost all the time based on social and economic relation. Access to resources can be varied between households and that have significant influence on potential loss and rate of recovery or relative resilience to disaster. Therefore those with relatively higher access to information, money, right to the production, equipment and social networks are lower the vulnerability to disaster, hence generally higher the capability to recover more quickly. A household sub-model is presented below (Figure: 1.4) to illustrate various aspects of access to resources to continue livelihoods and their associations between them. The term household is used in this model to refer as a distinct economic unit. However it could be a broader groups or community.[47]

Figure 1.4: Access to Resources to Maintain Livelihoods



Source: Adopted from John Twigg 2001, *Corporate social responsibility and disaster reduction: A global overview.*

---

[46] Terry Cannon, "Vulnerability Analysis and the Explanation of 'Natural' Disasters," *Disasters, Development and Environment* (1994): 13-30.

[47] John Twigg, *Corporate Social Responsibility and Disaster Reduction: A Global Overview* (London: Benfield Greig Hazard Research Centre, 2001).

The Asset Vulnerability Framework

Asset vulnerability framework explained both tangible assets like labor, human capital and productive assets; and intangible assets such as household relations and social capital as the vital assets determining household vulnerability. This study has uniformity with Blaikie *et al.* asset framework. It also defines outline the vulnerability to natural disasters. In this framework it is found that household vulnerability as a result of the cycles of resource accumulation and expenditure. A household can achieve adequate resources to sustain its members to prevent or absorb disaster losses.[48]

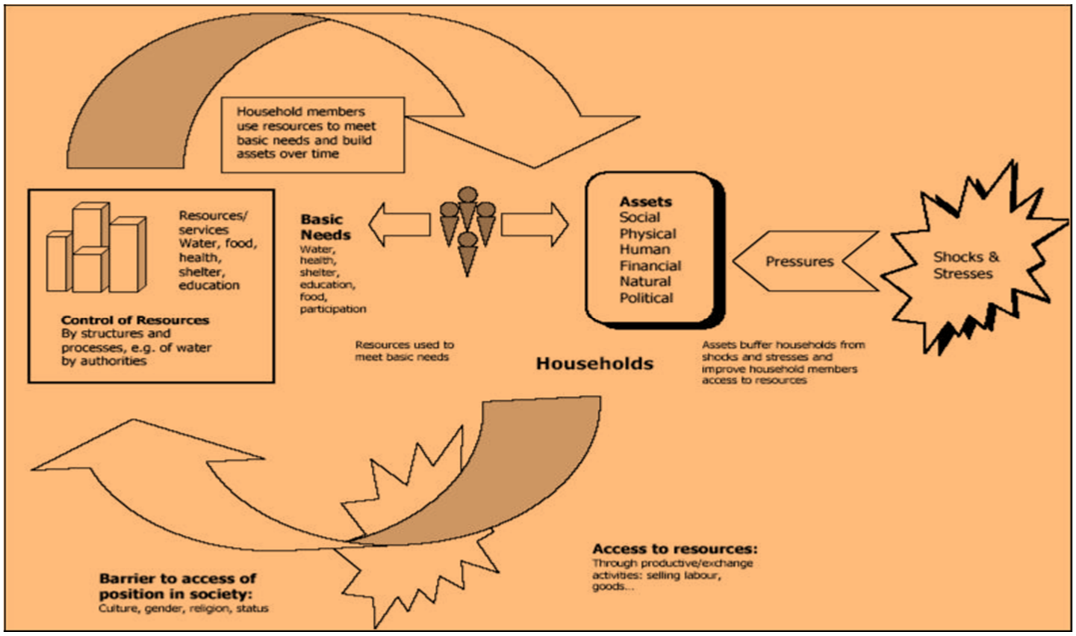
The Household Livelihood Security Model of Sanderson

This livelihood asset based model called household livelihood security model (Figure: 1.5) was developed by Sanderson in 2000. This model was applied in urban vulnerability reduction programmes executed by CARE International in several countries including Bangladesh. Here it was intended to integrate measures for eradicating poverty with lessening risks posed by environmental hazards in the city. In the line with previously mentioned access approach, this model also consider household as a unit for resource accumulation and management. This model paid attention on household's coping needs, supporting low income groups to diversify their asset base to reduce vulnerability to shocks and stresses (including disaster). It acknowledges both physical and non-physical assets, policies, regulations, linkage of micro and macro issues and links of local level with broader environment. In this model household livelihood assets are classified as social, physical, human, financial, natural and political.

---

[48] M. Pelling, *The Vulnerability of Cities* (London: Earthscan Publication Ltd., 2003), 46

Figure 1.5: The Household Livelihood Security Model of Sanderson

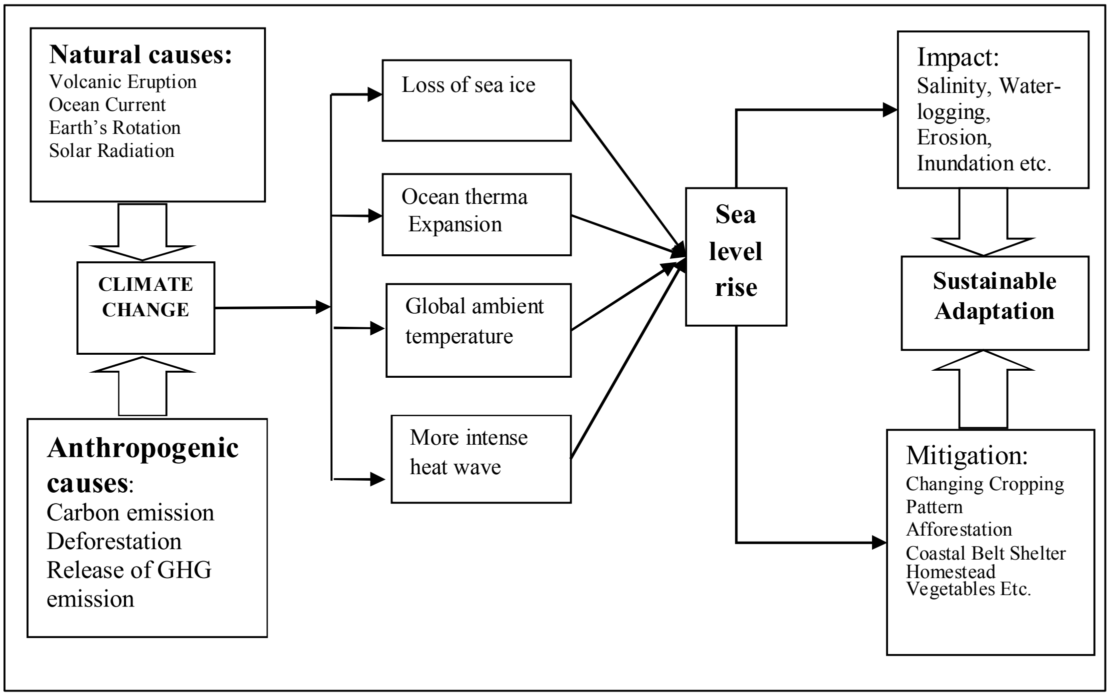


Source: Sanderson Household Livelihood Security Model, 2000.[49]

The study has designed to present a conceptual framework for assessing of vulnerability and adaptation to climate variability and change induced sea level rise, generally applicable to a wide range of contexts, systems and hazards.

[49] David Sanderson, "Cities, Disasters and Livelihoods," *Environment and Urbanization* 12, no. 2 (2000): 93.

Figure 1.6: Conceptual Framework of Sustainable Adaptation in Bangladesh Regarding Sea Level Rise



The Flowchart is developed by the Researcher.

Biophysical vulnerability is distinguished from social vulnerability, which is broadly evaluated by the natural hazards concept of risk. The IPCC definition of vulnerability is discussed within this context, which helps us to understand the definitions of vulnerability of sea level rise. The relationship between the vulnerability and adaptive capacity of human system critically depends on the nature of the hazard faced. Adaptation of a system depends on the rate of reducing obstacles originating outside the system. Therefore, it is important to consider external obstacles when assessing adaptive capacity.

1.12 Feasibility of the Study

The ongoing study was feasible in many ways. Supports for the successful completion of the study were available from the enriched library of IBS, Rajshahi University central library, Dhaka University library, BBS library and many other reputed libraries in the country. Another important support i.e. online access for all the students in any time helped to collect information through internet. All the learned teachers of Rajshahi University, IBS as well as the concerned supervisor's suggestions for the study were no doubt able to complete the study successfully by the stipulated three years of time. University Grant Commission's (UGC), Bangladesh fellowship met up the financial needs to execute the study.

1.13 Utility of the Study

The researcher is confident that the findings of the proposed research will be useful to the following categories of sectors and persons in many ways.

Government of Bangladesh: The findings of the study will help different Officials, Ministries, Policy makers, Planners of the Government of Bangladesh for making policies.

NGOs: In coastal areas of Bangladesh a good number of NGOs are working and they will be benefitted by the study in their field of works.

Academicians, Researchers: The academicians and researchers will be able to get information from the findings of the study. The study may be used as the secondary source for the further research.

1.14 Organization of the Dissertation

The dissertation has been organized in ten chapters. The review of relevant literature on climate change and sea level rise is presented in Chapter Two. It covers conceptualization, extent of sea level rise, salinity intrusion and livelihood insecurity and livelihood insecurity in the context of Bangladesh. Chapter Three discusses the methodology of the study. Chapter Four discusses the study area and respondent profile. Chapter Five which covers potential threats of sea level rise on coastal population and environment. Detail of livelihood assets of coastal population is placed in Chapter Six. Chapter Seven deals with the various techniques of adaptation measures chosen by coastal people in different scenarios of sea level rise. Chapter Eight deals with the support mechanism of different organizations. Chapter Nine deals with the factors influencing livelihood security, it also discusses the assessment of livelihood security in various adverse situations. Finally, Chapter Ten presents summary, policy implications and conclusions of the dissertation.

1.15 Chapter Summary

The impact of climate change induced sea level rise on livelihood pattern in coastal areas aggravates the vulnerability to different coastal communities and socio-economic classes of the society. Coastal infrastructure and ecosystem are not only the assets for the coastal communities but also very important for the economy of the whole country. The coastal zone of Bangladesh is the worst victim of sea level rise having negative impact on the coastal population including salinity intrusion, river bank erosion, lack of safe drinking water and decreasing food production. The present study attempted to assess overall impact on livelihood security induced by sea level rise in the coastal zone of Bangladesh. Finally, this study tried to give some policy recommendations for the policy makers so that they can formulate needed policies to reduce the intensity of the impact of sea level rise and strengthen the security of livelihood of coastal inhabitants of Bangladesh.

Chapter Two
Literature Review

2.1 Introduction

Bangladesh is extremely vulnerable to climate change induced sea level rise because of its low-lying deltaic physiographic feature. Vulnerability due to climate change has been investigated earlier by a good number of researchers in Bangladesh. Among them some studies unveiled the adverse impacts of climate change for Bangladesh regarding sea level rise.

Accelerated sea level rise involves an in-depth analysis of a wide range of literature relating to such topics as climate change, impact of sea level rise and planning response including certain strategy. Climate change induced sea level rise is not a separate issue for a country like Bangladesh, it is a global issue. Extensive review of literature has been done to capture different aspects of climate change induced sea level rise.

For quite a few decades studies on climate change induced sea level rise and coastal vulnerabilities have become a major concern for Geographers and Environmental scientists all over the world. A significant number of theories, models, techniques and analysis have been used to understand the scenarios of sea level rise. All these works have analyzed the climate change and its impact on environment especially in the coastal region. Significant works are rare regarding impact of sea level rise on livelihoods especially for the coastal region of Bangladesh.

This chapter describes and analyzes the concepts and approaches related to impacts of climate change induced sea level rise on livelihood and adaptation. It is divided into five main sections as

Section 2.2.1. discusses about relevant concepts of climate change,

Section 2.2.2. considers the concepts of impact, approaches to assess impacts of climate change and the review of impacts of climate change induced sea level rise,

Section 2.2.3. describes sea level rise related salinity intrusion and relevant concepts of adaptation, adaptation approaches and adaptation typologies,

Section 2.2.4. explains the reviews related to sea level rise and livelihood security and

Section 2.2.5. discusses the concept of sustainable livelihood and livelihood security.

2.1.1 Reviews on Relevant Concepts of Climate Change

IPCC (2001) stated that the weather average during a period of time is called climate. According to the Intergovernmental Panel on Climate Change, “climate is usually defined as the “average weather”, or more rigorously, as the statistical description of the weather in terms of the mean and variability of relevant quantities over periods of several decades”.[1] The quantities include primarily temperature, precipitation and wind variables.

Ylva Uggla (2010) defined climate change as “any change in climate over time whether due to natural variability or as a result of human activity”.[2] “Climate change refers to a change in the state of the climate that can be identified (e.g., using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer”.[3]

IPCC (2007) reports revealed that climate change can be understood as the long-term change in temperature and precipitation average whether high or low. But climate change not only refers to changing means of variables over a long period of time. The frequency and intensity of extreme climate events such as droughts, floods, storms and hurricanes, are also part of global climatic change. Several scholars argue that the frequency and intensity of extreme weather events is increasing. [4]

Osvaldo F. Canziani et al. (2007) explained that the extreme events regarding climate change are defined as infrequent events of a particular weather or climate based on their deviation from average range of temperature, precipitation and wind. According to the IPCC, “an extreme weather event is an event that is rare at a particular place and time of year”. “When a pattern of extreme weather persists for some time such as a season, it may be classed as an extreme climate event”. Extreme weather and climate events both include droughts, floods, tropical cyclones, and strong winds, hot days and nights, cold days and nights.[5]

---

[1] IPCC, Climate change 2001, "Maximum and Minimum Temperature Trends for the Globe." Intergovernmental Panel on Climate Change. Available at: https://scholar.google.com/scholar?hl=en&q= IPCC%2C+1997%2C+p. + 9&btnG=&assdt=1%2C5&as_sdtp (accessed 11March 2016).

[2] Ylva Uggla, “What is this thing Called ‘Natural'? The Nature-Culture Divide in Climate Change and Biodiversity Policy," *Journal of Political Ecology* 17 (2010): 79.

[3] M. R. Allen Pall and D. A. Stone, "Testing the Clausius–Clapeyron Constraint on Changes in Extreme Precipitation under CO2 Warming," *Climate Dynamics* 28, no. 4 (2007): 352.

[4] IPCC, Climate Change 2007: *Synthesis Report*. Intergovernmental panel on climate change. Available at: http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf (Accessed 12 May 2016).

[5] Osvaldo F. Canziani, Jean P. Palutikof, Paul J. van der Linden and Clair E. Hanson, *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Edited by Martin Parry. Vol. 4. (Cambridge: Cambridge University Press, 2007), 211-212.

According to the IPCC (2001), the increase of average surface temperature of the earth was already indicated in 1861. Global warming is an unprecedented phenomenon in the historical development of the earth climate system. The temperature has increased by $0.74^{o}C$ within 100 years from 1906 to 2005. On average, the earth surface temperature increased by approximately $0.074^{o}C$ every decade. However, this average rise differs considerably per time scales and geographical regions. For instance, the average rise in temperature in recent 50 years is twice as much as the average rise of 100 years 0.13^{o} C/decade. The rise in temperature measured at the North Pole is nearly twice as much compared to the global rise 1.5^{o} C/100 years.

IPCC (2007) found that temperature increases, glaciers at the North Pole, South Pole and Greenland have started to melt at an increased rate. When the snow and ice cover melts, huge quantity of water joins the oceans which leads to an immediate rise in sea-level. The global sea-level rose on an average 1.8 mm/year from 1961 to 2003, and the trend is on rise in recent years.[6]

Robert J. Nicholls (2008) explored that the increasingly human-induced pressures such as overpopulation, poverty, natural resource degradation, environmental pollution aggravates the impacts of climate change. The impacts of climate change in the developing countries are not caused by climatic factors but also non- climatic factors such as socio-economic, culture and others. For this reason it is very difficult to assess precisely what the impact is of climate change on rural livelihood security.[7]

To some extent, the impacts of climate change on different sectors - for instance, agriculture, fishery and livestock as well as systems - for instance, natural and human are assessed by a number of scientists and organizations.

The impact of climate change induced sea level rise on marine species, fishery and coastal residents is the focus of the research which is detailed in the following sections.

---

[6] IPCC, Climate Change 2007: *Synthesis Report*. Intergovernmental panel on climate change. Available at: http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf (Accessed 12 May 2016).

[7] Robert J. Nicholls, Poh Wong, Virginia Burkett, Colin D. Woodroffe, and John Hay, "Climate Change and Coastal Vulnerability Assessment: Scenarios for Integrated Assessment," *Sustainability Science* 3, no. 1 (2008): 89-102

2.1.2 Reviews Related to Climate Change induced Sea Level Rise

M Shamsul Alam and Kabir Uddin (2013) examined that climate change and its associated sea-level rise are expected to significantly affect vulnerable coastal communities. Sea level will rise up to 1 meter by the middle of 21st century; it combines a 90 cm rise in sea level and about 10 cm local rise due to subsidence. A potential future sea level rise for Bangladesh is 30-50 cm by 2050 has been revealed by the Pilot study of Department of Environment. An increasing tendency in sea level rise from west to east along the coast of Bangladesh has also been found.[8]

Anwar Ali (1999) showed that Bangladesh is situated at the boundary of two dissimilar environments, with the Bay of Bengal to the south and the Himalayas to the north which is an exceptional physiographic situation that does not give only livable environment but also produces catastrophic depredation of natural disasters including hydrological events. Climate change induced sea level rise is issue has become vital issue for its geographical location. For this the topography of the beach, the level of human intervention will determine the extent of the area to be flooded and the rate at which the shoreline will move inland. A detail investigation of Climate change induced sea level rise is found in his study.[9]

The most recent report of intergovernmental panel on climate change (IPCC, 2007) Bangladesh is identified as being at particular risk from climate change as it is in a low lying coastal region. Thousands of scientists and other experts contributed to the reports. The reports cover the impact of climate change. Most of the adverse effects of climate change induced sea level rise will be in the form of extreme weather events, despite the fact that water-related hazards such as flood, salinity ingress, bank erosion, and tidal bore are likely to be exacerbated and these will lead to large scale damages to crop, employment, livelihoods, and national economy.[10]

---

[8] M Shamsul Alam and Kabir Uddin, "A Study of Morphological Changes in the Coastal Areas and Offshore Islands of Bangladesh Using Remote Sensing," *American Journal of Geographic Information System* 2, no. 1 (2013): 15-18.

[9] Anwar Ali, "Climate Change Impacts and Adaptation Assessment in Bangladesh," *Climate Research* 12, no. 2-3 (1999): 109-116.

[10] Md Zahurul Haque and Md Saifuzzaman, "Social and Environmental Effects of Shrimp Cultivation In Bangladesh: Notes On Study Methods," *Globalization, Environmental Crisis and Social Change In Bangladesh, Dhaka, Bangladesh, UPL. [Links]* (2003): 1-19. Available at https://www.researchgate.net/publication/265080498 (accessed on 15 April 2016).

John T. Houghton et al. (2001) analyzed according to scientific evidence that the emissions of greenhouse gases originating from anthropogenic sources significantly affect the earth's climate primarily by an increase of the global mean temperature. It increases water temperature as a result sea water expands. In the study it is found that this temperature promotes the melting of glaciers which is also considered the cause of sea level rise.[11]

Boateng Isaac (2012) showed in his study that sea level rise due to climate change is a serious global threat and major coastal issue in the 21st century, because many of the world's infrastructures and people are located in the coastal zone. Rising sea level has such consequences as coastal erosion, increased flood risk, and salt water intrusion. Both human development and naturals habitats are at risk when sea level rises**.**[12]

IPCC (2007) explored that the atmospheric temperature is rising due to anthropogenic and natural causes. For this, the atmosphere and the ocean have warmed. Accordingly, the amount of snow and ice has diminished, sea level has risen and the concentration of greenhouse gases has increased. Analysis from the data available in tide gauge it is seen that the global sea level rise was found to fluctuate between 0.1 to 0.2 m in the 20th century.[13]

Robert J. Nicholls and Nobuo Mimura (1998) stated that warming of the climate system is undeniable and since the 1950s, many of the observed changes are unprecedented over a long period of time. An enhancement of the global mean temperature will lead to accelerated glacial melting (eustatic change) which combined with thermal expansion (steric change) of ocean water will raise global sea level. The impact assessment of climate change has been narrated by Nicholls who reviewed the global sea level rise. This analysis gives a brief indication of the issue, and in doing so he pays attention to various sources of uncertainty. As Nicholls points out, global mean sea level rise is one of the more certain impacts of global warming. However, the assessment gives a frightening picture that sea level rise contains considerable uncertainty. Simultaneously to go on the review of sea level rise, it would be useful to remind ourselves of the problems coastal areas are currently confronting. According to the IPCC's SRES scenarios, sea level will rise by between 18

[11] John T. Houghton, D. L. Albritton, L. G. Meira Filho, U. Cubasch, X. Dai, Y. Ding, D. J. Griggs et al. *Technical Summary of Working Group 1*. (Cambridge University Press: 2001), 15-22.

[12] Boateng Isaac, "An Assessment of The Physical Impacts of Sea-Level Rise and Coastal Adaptation: A Case Study of the Eastern Coast of Ghana," *Climatic Change* 114, no. 2 (2012): 273-293.

[13] IPCC, Climate Change 2007: *Synthesis Report*. Intergovernmental Panel on Climate Change. Available at: http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf (Accessed 12 February 2016).

and 59 cm by the end of the 21st century. In the most terrible case scenario, which would be a subsidence of the west Antarctic ice sheet (WAIS), the sea level, might rise with as much as 5 to 6 m over a period of 100 years. The size of the ice caps has fluctuated greatly over time and the sea level has been raised higher than at present. The big difference is now that the world is now much more densely populated than ever before and millions of people would therefore be affected if sea levels were to rise.[14]

Grahame Russell (1999) found that the global climate is changing according to the scientific agreement of an overwhelming association of evidence. Due to the time scales involved in climate processes, the anthropogenic warming of the global climate and Sea level rise (SLR) will continue, regardless of whether a stabilization of greenhouse gas concentrations were to take place or not. In his study it revealed that anthropogenic causes are involved in climate change which will trigger sea level rise.[15]

Tom ML Wigley and S. C. B. Raper (1987) stated that the literature on sea-level rise is extensive and a number of good reviews are accessible. Possibly, the reports by the Intergovernmental panel on climate change (IPCC) are the most consistent, where the Causes and the impacts of climate change induced sea level rise have been mentioned. Different stages of future sea level rise have been narrated in the study. For different period he made a projection about the scenario of changing sea level rise which gives an extensive idea. Thermal expansion is important factor for sea level rise. Analysis from thermal expansion it is observed that the Greenland ice sheet will gradually melt and contributes its water to the oceans which will increase the sea level rise. Thermal expansion induced sea level rise was 2-5 cm between 1880 and 1985 and there is more estimation that between 1985-2025 is 4-8 cm when greenhouse induced warming estimated as 0.6 to 1.0° C.[16]

R.A. Warrick and J. Oerlemans (1990) showed that the possibility of future rise in sea level is a great concern to Bangladesh which has a low lying and densely populated deltaic Coast. Especially the coastal and nearby areas along the Bay of Bengal are most

---

[14] Robert J. Nicholls and Nobuo Mimura, "Regional Issues Raised by Sea-Level Rise And Their Policy Implications," *Climate Research* 11, no. 1 (1998): 5-18.

[15] Grahame Russell, "Hurricane Mitch and Human Rights," *Development in Practice* 9, no. 3 (1999): 322-325.

[16] Tom ML Wigley and S. C. B. Raper, "Thermal Expansion of Sea Water Associated with Global Warming," *Nature* 330, no. 6144 (1987): 127-131.

vulnerable due to SLR. It may cause more soil erosion, inundation of land, salinity of soil and water and flooding storm surges than the past. But the occurrence of such calamities is uncertain. The best estimate based on recent analysis is that the sea level has risen about 18 cm over the last 100 years with a range of uncertainty of 10 - 25 cm. It is estimated the annual average precipitation in the Chittagong region is 2730 mm which is the highest in South Asia. The sea-level rise that has been observed over the last century poses a significant threat to coastal zones throughout the world. The effect of sea level rise is dangerous to Bangladesh for several reasons. In Bangladesh, run-off, sediment flow, and deposition rates have been attributed to changes in the flood defense systems. Simultaneously, deforestation in the region contributed to disadvantageous effects on coastlines of Bangladesh. The increasing frequency and severity of island flooding impact the fishery sector of the coastal zone of Bangladesh.[17]

According to Intergovernmental Panel on Climate Change, a significant portion of land will be inundated by saline water which will degrade the fertility of the largest amount of cultivated land globally due to rising sea level. Accordingly, Bangladesh's agriculture is very sensitive to impact of climate change. Only a meter rise in sea level would inundate 20% of the country's landmass. The Panel reported that prolonged inundation, increased drought, salinity and loss of land due to erosion are the enhanced risk that agriculture is facing due to climate change. Increased drought and Stalinization in the dry season and prolonged inundation in the wet season will change the areas suitable for growing crops in coastal region.[18]

2.1.3 Reviews Related to Sea Level Rise and Salinity Intrusion

Ahsan Uddin Ahmed, Mozaharul Alam, and A. Atiq Rahman (1999) examined that the normal increase in temperature in Bangladesh would be 1.3°c and 2.6°c by the year 2030 and 2075 respectively with respect to the base year 1990. Sea level rise will cause river bank erosion, salinity intrusion, flood, damage to infrastructures, crop failure, destruction of fisheries, loss of biodiversity etc. along the coast. Climate change induced Sea level rise has various impacts on Bangladesh; salinity intrusion is the worst of them. Its possible threat is coming strappingly in future on the coastal area of Bangladesh. [19]

---

[17] R.A. Warrick and J. Oerlemans, *Sea Level Rise*. In: *Climate Change, The IPCC Scientific Assessment.* J.T. Houghton, G.J. Jenkins, J.J. Ephraums (eds.), (IPCC: 1990), 260-281.

[18] ICCAD, *Briefing-for-Bangladesh,* available at *www.icccad.net/wp-content/uploads/2015/01/IPCC-Briefing-for-Bangladesh.pdf (Accessed 11 January 2017)*

[19] Ahsan Uddin Ahmed, Mozaharul Alam and A. Atiq Rahman, "Adaptation to Climate Change in Bangladesh: Future Outlook," In *Vulnerability and Adaptation to Climate Change for Bangladesh*, (1999): 125-143.

Anwar Ali (1999) found that Bangladesh is predominantly agricultural country. Moreover, the coastal population of the country basically depend on agriculture. Soil salinity is the adverse impact of sea level rise in Bangladesh which makes the coastal region vulnerable. It has created a problem which is not only reducing the agricultural productivity but also putting extensive impacts on living strategies of farmers.[20]

Anny Cazenave and R. Steven Nerem (2002) showed detail in the third assessment report by the IPCC, where the detail descriptions regarding climate change has been stated. Moreover, there are some outstanding explanations regarding salinity intrusion and their impacts on the inhabitants living in coastline are revealed in the review paper.[21]

Md Zahurul Haque and Md Saifuzzaman (2003) explored that climate change putting extensive impacts on living strategies of farmers especially on coastal area of Bangladesh. Soil and water salinity have adverse impact on people's living standard, daily activities and socio-economic conditions. Salinity intrusion in the fresh water and agricultural land is a major constraint for agricultural production.[22]

Jessica M. Ayers and Saleemul Huq (2009) showed that sea level rise increases salinity intrusion to the land area which causes saline water infectivity to the sweet surface water. So, the coastal people are forced to use expensive deep tube well for drinking water. The NAPA tried to figure out possible impacts of climate change with issues of livelihood concerns. Climate change is expected to have major physical impacts on agriculture, industry, infrastructure, disaster, health and energy and consequently on people's livelihood in terms of employment, income and consumption.

Bangladesh is one of the most vulnerable countries to both short term climate shocks, e.g.; cyclones, floods, prolonged droughts etc., and long term risk of climate change in the form of sea level rise. The coastal districts of Bangladesh are already experiencing the effects of climate change through increased frequency of cyclones and salinity of

[20] Anwar Ali, "Climate Change Impacts and Adaptation Assessment in Bangladesh," *Climate Research12*, no *12*(1999), 109-116.

[21] Anny Cazenave and R. Steven Nerem, "Redistributing Earth's Mass," *Science* 297, no. 5582 (2002): 783-784.

[22] Md Zahurul Haque and Md Saifuzzaman, "Social and Environmental Effects of Shrimp Cultivation in Bangladesh: Notes on Study Methods," *Globalization, Environmental Crisis and Social Change in Bangladesh, Dhaka, Bangladesh, UPL. [Links]* (2003): 1-19. Available at https://www.researchgate.net/publication/265080498 (accessed on 15 April 2016).

agricultural land resulting from saltwater intrusion due to rising sea levels, cyclone and storm surges and upstream withdrawal of freshwater. Climate change induced vulnerabilities are affecting food security, livelihood, health status and social security in the climate hotspots in Bangladesh. [23]

Kerry Black and Shaw Mead (2001) narrated that sea level rise impacts are projected to cause multiple negative consequences in coastal zones such as coastal erosion, flooding, flood-related health problems, property damage, and socio-economic impacts. Thus, it is very important to assess adaptation measures to minimize these devastating projections. Several strategies have been developed to respond the effects of sea level rise such as Retreat, accommodate, Protect. Within the protect responsive strategy, hard and soft adaptation options have been widely implemented in coastal zones. The soft adaptation options like beach nourishment, dune restoration, afforestation and reforestation, and marine soft engineering technology etc. are well known, which provide important possibilities in response to sea level rise in coastal zones. Advantages and disadvantages of these soft options are analyzed from an ecological and socio-economic perspective.[24]

2.1.4 Reviews Related to Sea Level Rise and Livelihood Security

Jessica M. Ayers and Saleemul Huq (2009) revealed that sea level rise has adverse impacts on the livelihood of coastal population; most of the people of coastal area depend on agriculture. From the analysis of erosion, accretion and net gain or loss of land in coastal areas and offshore islands of Bangladesh it is seen that the coastal people face problem in agricultural production. Salinity intrusion from sea level rise into the main land severely affects the crop production. The analysis also revealed that this type of natural process will make millions of people environmental refugees.[25]

The global community certified the newest findings of the Inter-Governmental Panel on Climate Change (IPCC) through its Fourth Assessment Report (AR4) that the average earth's temperature might increase up to 7^{0}C with respect to 1990 values by 2100. This

[23] Jessica M. Ayers and Saleemul Huq, "The Value of Linking Mitigation and Adaptation: A Case Study of Banglades, " *Environmental Management* 43, no. 5 (2009): 753-764.

[24] Kerry Black and Shaw Mead, "Wave Rotation for Coastal Protection," In *Coasts & Ports 2001: Proceedings of the 15th Australasian Coastal and Ocean Engineering Conference, the 8th Australasian Port and Harbor Conference*, p. 120. Institution of Engineers, Australia, 2001 available at http://gbr.o2o.com.au/WaveRotator% 20coastal%20protection.pdf (accessed on 15 June 2016).

[25] Mohammed Fazlul Karim and Nobuo Mimura, "Impacts of Climate Change and Sea-Level Rise on Cyclonic Storm Surge Floods in Bangladesh," *Global Environmental Change* 18, no. 3 (2008): 490-500.

rise is associated with increasing rates of melting of permafrost (i.e., icebergs, ice sheets, glaciers, etc.), increasing sea level, flood and salinity intrusion vulnerability in many other parts of the globe. It is feared that the poorest of the vulnerable countries will be the worst hit and the overall burden of adverse impacts of climate change will be disproportionate on the poor communities like Bangladesh. There is a relation between vulnerability of coastal population with coastal hazards and sustainable livelihoods. Their study found that the capacity of coastal people to secure themselves from the threat is constrained by fragile livelihood system. The study remarked that sustainable adaptation measures need to be taken to secure people from vulnerabilities and enhance the strength to face the adverse impacts.[26]

Md Modasser Hossain Khan et al. (2015) explored that the coastal belt population is poorest section of the country; they mainly depend on agriculture, fisheries, small trade, wage labor who are very much vulnerable to climate change. This vulnerability affects their livelihoods and reduces their income facilities and pushes them in food insecurity. The livelihood security of coastal zone population which is under various kinds of problems, such as higher than national average population growth, habitat destruction, increased pollution, decreased of crop production etc. Policy makers, planners and experts of coastal zone will face many kinds of problems and they would have to solve the different problems simultaneously, sea level rises being only the important one of them. In the future toward the end of 21st century, coastal zone experts are expected to deal with increasing coastal population and impact of sea level rise on their livelihoods security.[27]

Mahbuba Nasreen, K. M. Hossain and M. A. K. Azad (2013) examined that most of the coastal people of Bangladesh are considered food insecure due to climatic events like flood, storm, river bank erosion, salinity intrusion etc. The poor are becoming more vulnerable because of crop loss which is a consequence of climate change. Coastal people are to fight always with impact of climate change and they are to take alternative occupation to secure their livelihood.[28]

---

[26] Jean-Christophe Gaillard, Emmanuel A. Maceda, Elodie Stasiak, Iwan Le Berre and Maria Victoria O. Espaldon, "Sustainable Livelihoods and People's Vulnerability In the Face of Coastal Hazards," *Journal Of Coastal Conservation* 13, no. 2-3 (2009): 119.

[27] Md Modasser Hossain Khan, Ian Bryceson, Korine N. Kolivras, Fazlay Faruque, M. Mokhlesur Rahman and Ubydul Haque, "Natural Disasters and Land-Use/Land-Cover Change in the Southwest Coastal Areas of Bangladesh," *Regional Environmental Change* 15, no. 2 (2015): 241-250.

[28] Mahbuba Nasreen, K. M. Hossain and M. A. K. Azad, "Climate Change and Livelihood In Bangladesh: Experiences Of People Living In Coastal Regions," *Proce. of Int. Con. of Building Resilience* (2013): 1-25.

Saleemul Huq et al. (2004) showed that coastal zone of Bangladesh is vulnerable to climate change and the inhabitants are to force to take alternative strategy for securing themselves from the impact of the disaster. The total scenario has a great impact on the economy of the country. Proper initiatives and programs can relieve the distressed population from effect of such insecurities.[29]

Md Golam Mahabub Sarwar (2005) examined that over the last one decade, Bangladesh has warmed up by about 0.5^{o}C and 5 mm rise of sea level in the Bay of Bengal. One meter sea level rise will affect the vast coastal area and flood plain zone of Bangladesh. Both livelihood options of coastal communities and the natural environment of the coastal zone will be affected by the anticipated consequences of sea level rise. It will also affect national and food security of the country. As Bangladesh's population are at risk of sea level rise which is predicted to rise to 27 million by 2050. Global mean sea level could be almost a meter higher by the end of the century, under a scenario with high emissions. Climate change also creates risk for food security. Under a scenario of low crop productivity because of salinity intrusion in agricultural land, Bangladesh could experience a net increase of poverty of 15% by 2030.[30]

Shardul Agrawala et al. (2003) found that sustainable coastal zone management is closely related with the impact of sea level rise. Bangladesh is highly populated country and coastal population is agriculture dependent. So, livelihood security of the people of coastal region should be considered regarding the impact of SLR. Bangladesh has recently been ranked as the most climate vulnerable country in the world. Floods, tropical cyclones and river erosion are the costliest natural catastrophes in Bangladesh and account for a significant proportion of damage, injury and loss of life and livelihoods .Bangladesh currently has extreme vulnerability to cyclones, on account of its somewhat unique location and topography. Climate change related sea level rise and other hydro-meteorological effects could have a catastrophic impact on the Sundarbans mangrove

[29] Saleemul Huq, Hannah Reid, Mama Konate, Atiq Rahman, Youba Sokona and Florence Crick, "Mainstreaming Adaptation to Climate Change In Least Developed Countries (LDCs)," *Climate Policy* 4, no. 1 (2004): 25-43.

[30] Md Golam Mahabub Sarwar, "Impacts of Sea Level Rise on the Coastal Zone Of Bangladesh," *See http://static. weadapt.org/placemarks/files/225/golam_sarwar. pdf* (2005). (Accessed on 16 June 2016).

ecosystems and surrounding human settlements. A high intensity event in 1986 devastated the Sundarbans and drowned thousands of its magnificent animals including the threatened species.[31]

Saleemul Huq (2001) showed that in the year 2020, the estimated population of Bangladesh will be 170 million and population density 1118 per sq. km. Seventy per cent of the country's land is currently under cultivation. Land resources for agriculture consist approximately of nine million hectares which provides a per capita figure of 13 persons per ha. With the population reaching 170 million by 2020, this figure will increase to 20 persons per hectare counting the possible loss of cultivable land to alternative uses like housing, urbanization, etc. The pressure of the rising number of people on finite amounts of land, water and other natural resources has already resulted in mounting deforestation (a reduction from 10 to 6% in forest cover) that may become irreversible within the next 20 years. Increasing salinity by sea level rise and water logging in cultivated land, declining water tables, high levels of erosion in the hills will worsen the livelihood security. The riches of floodplain fisheries and wetlands have all been depleting dangerously, caused by both natural forces and human interventions. If the negative trends cannot be reversed, they could reduce the current levels of fish production by 12 – 14 per cent. If the current two per cent per year deforestation rate is not reversed at all, the country's forests will probably disappear totally by 2020, and with them vanish the centuries old heritage of biodiversity.[32]

Global Facility for Disaster Reduction and Recovery (GFDRR, 2011) found that global sea levels have risen through the 20th century. These rises will almost certainly accelerate through the 21st century and beyond because of global warming, but their magnitude remains uncertain. Key uncertainties include the possible role of the Greenland and West Antarctic ice sheets and the amplitude of regional changes in sea level. In many areas, non-climatic components of relative sea level change (mainly subsidence) can also be locally appreciable. Although the impacts of sea-level rise are potentially large, the application and success of adaptation are large uncertainties that require more assessment and consideration. The physical impacts of SLR are well known. The immediate effect is

[31] Shardul Agrawala, Tomoko Ota, Ahsan Uddin Ahmed, Joel Smith and Maarten Van Aalst. "Development and climate change in Bangladesh: focus on coastal flooding and the Sundarbans," *OECOD, France* (2003):1-70.

[32] Saleemul Huq, "Climate change and Bangladesh," *Science* 294, no. 5547 (2001): 1617-1617.

submergence and increased flooding of coastal land, as well as saltwater intrusion of surface waters. Longer-term effects also occur as the coast adjusts to the new conditions, including increased erosion and saltwater intrusion into groundwater. Coastal wetlands such as salt marshes and mangroves will also decline unless they have a sufficient sediment supply to keep pace with SLR. These physical impacts in turn have both direct and indirect socioeconomic impacts, which appear to be tremendously with negative effects.[33]

World Bank (2013) found that forests are the most diverse and widespread ecosystems on earth and millions of people living in most tropical countries derive a significant part of their livelihoods from various forest products for centuries. These products also play a vital role to the livelihoods of people living in or adjacent to forests. According to the World Bank, more than 1.6 billion people throughout the world relying heavily on forests for their livelihoods and some 350 million people depends only on forest both for their subsistence and income. Over two billion people, a third of the world's population, use biomass fuels, mainly firewood, to cook and heat their homes, and billions rely on traditional medicines for their ailment harvested from the forests. In some 60 developing countries, hunting and fishing on forested land supplies a significant amount of the protein requirements. Some estimates suggest that, part of South East Asia's tropical forest promote up to 50 US$ per month per hectare to local people from exploiting forest resources, without considering the commercial timber values. So, it is doubtless that forestry plays an important role for coastal livelihood .The forests adjacent to sea (like Sundarbans) are under serious threat of sea level rise as the significant portion will be lost by inundation of saline water.[34]

Md Mustafa Saroar, Jayant K. Routray and Walter Leal Filho (2015) explored that the livelihood of about 35 million natural resource-dependent coastal populations would be severely affected by SLR and its associated events, a significant proportion of them might turn out as climate migrants by the middle of this century. The issues of climate change induced displacement and climate migrants already have been appeared as serious concern for Bangladesh and its neighboring countries as well. Drawing from the evidences of previous migration patterns in the Indian subcontinent, many scholars have warned that huge displacement from coastal Bangladesh may eventually drag Bangladesh

[33] GFDRR, *climate Change,* available at http*://wb_gfdrr_climate_change_country_profile_ for_BGD.pdf* (Accessed on 17 July 2016).

[34] World Bank, available at http://www.worldbank.org/en/news/press-release/2013/06/19/warming-climate-to-hit-bangladesh-hard-with-sea-level-rise-more-floods-and-cyclones-world-bank-report-says (Accessed on 17 June 2016).

in violent conflict with neighboring India, Pakistan and Myanmar as many climate migrants may arrive in these neighboring countries following some historical links (i.e. cultural, religious and ethnic). Such massive displacement from the vulnerable coast of Bangladesh could be reduced by reducing the vulnerability of the coastal population.[35]

Md Shahadat Hossain (2001) explained that gradually the intensity of disasters like sea level rise, tidal surge, salinity intrusion and cyclone in coastal belt is being increased. The salinity intrusion by sea level rise is a major factor which impedes the crop production at large in the coastal belt. Coastal agriculture is being seriously affected by different levels of climatic risks caused by integrated effects of the following factors like soil salinity, water salinity, sea level rise, tidal surge, cyclone, heavy soils, soil wetness/water stagnancy, fallow/seasonal fallow land, incidence of pests and diseases, poor marketing infrastructure, problem of agro-based industries, poor health, livelihood, fishermen's are jobless, migration to cities, unsafe drinking water, etc. The coastal belt is highly vulnerable due to the climate change induced sea level rise.[36]

R. A. Warrick et al. (1996) showed that the impact of climate change regarding SLR on environment is uncertain. It may be disadvantageous for some regions and species and for others. It is noted that the composition and geographic distribution of many ecosystems will shift as individual species respond to changes in climate. There will likely be reductions in biological diversity and in the goods and services that nonforest terrestrial ecosystems provide to society. Over the past 100 years, Bangladesh has experienced an increase of temperature about 5°C and this warming trend is consistent with that of the northern Hemisphere as a whole. Based on global climate change, the IPCC estimated that Bangladesh will be O°C to 2°C warmer than today in the year 2030. The most adverse consequence is that sea level rise which will influence vegetation, soil and animal resources upon which the people of Bangladesh depend for food and other necessities. Moreover, it is important to note that the forest area in this region is decreasing at a high rate so many plants and animals are becoming extinct. SLR plays an important role in the sustenance of large ecological diversity in Bangladesh and south Asian region as a whole.[37]

---

[35] Md Mustafa Saroar, Jayant K. Routray and Walter Leal Filho, "Livelihood Vulnerability and Displacement in Coastal Bangladesh: Understanding the Nexus," In *Climate Change in the Asia-Pacific Region*, pp. 9-31. Springer International Publishing, 2015.

[36] Md Shahadat Hossain, "Biological Aspects of the Coastal and Marine Environment of Bangladesh," *Ocean & Coastal Management* 44, no. 3 (2001): 261-282.

[37] R. A. Warrick, G. J. Kenny, G. C. Sims, N. J. Ericksen, Q. K. Ahmad and M. Q. Mirza, "Integrated Model Systems for National Assessments of the Effects of Climate Change: Applications in New Zealand and Bangladesh," In *Climate Change Vulnerability and Adaptation in Asia and the Pacific*, Pp. 215-227. Springer Netherlands, 1996.

Abu Muhammad Shajaat Ali (2006) attempted to describe that SLR is a great threat for forests situated near at sea. Forest in coastal zone plays an important role in maintaining the global eco- system in balance and these forests are also the largest carbon sink above the soil. Deforestation for fuel wood or cooking has adverse effect on both people and the environment, including degradation of surrounding ecosystems, reduced crop yields, loss of biodiversity, reduced timber supply, flooding, siltation, soil degradation and climate irregularities. This has serious negative impact on coastal livelihood.[38]

Saleem-ul Huq, Ahsan U. Ahmed and Rob Koudstaal (1996) reported that the crop yield would be negatively impacted by rise in temperature, erratic rainfall, flooding, droughts, salinity etc. and among which water logging and drainage congestion are the major problems. The ecological conditions are more vulnerable due to climate change and sea level rise. The major impacts of climate change in agriculture sector have been narrated by the study.[39]

Anwar Ali (1999) assessed long-term impacts and vulnerabilities on crop production due to climate change in the coastal areas of Bangladesh, it has been suggested that appropriate coping strategies and adaptation options are to be considered for improving coastal agriculture. Moreover it is necessary to increase agricultural production and better livelihood options for the vulnerable farming communities in the coastal region of Bangladesh. [40]

2.1.5 Concept of Sustainable Livelihood and Livelihood Security

Livelihoods are explained as an array of assets arrangement approaches of production, consumption, and exchange for enhancing human living conditions.[41] It is the ways through which people assure their needs, or achieve a living and preferably add to wellbeing.[42] Livelihoods are secure if households have secure access, rights or ownership to resources and income earning activities which includes reserves and assets to face risk, alleviate shocks and

[38] Abu Muhammad Shajaat Ali, "Rice to Shrimp: Land Use/Land Cover Changes and Soil Degradation in Southwestern Bangladesh," *Land Use Policy* 23, no. 4 (2006): 421-435.

[39] Saleem-ul Huq, Ahsan U. Ahmed and Rob Koudstaal, "Vulnerability of Bangladesh to Climate Change and Sea Level Rise," In *Climate Change and World Food Security*, pp. 347-379. Springer Berlin Heidelberg, 1996.

[40] Anwar Ali, "Climate Change Impacts and Adaptation Assessment in Bangladesh," *Climate research* 12, no. 2-3 (1999): 111.

[41] John Twigg, *Corporate Social Responsibility and Disaster Reduction: A Global Overview* (London: Benfield Greig Hazard Research Centre, 2001), 12-14.

[42] Robert Chambers and Gordon Conway, *Sustainable Rural Livelihoods: Practical Concepts for the 21st Century* (UK: Institute of Development Studies, 1992), 5-9.

meet contingencies. Mostly earlier sustainable livelihoods definitions are relatively narrow and sometimes not clear and inconsistent. Therefore, following Chambers and Conway (1992), most widely cited definition of sustainable livelihood is given below:

> A livelihood comprises the capabilities, assets (stores, resources-tangible; claims and access-intangible) and activities required for a means of living: a livelihood is sustainable which can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation; and which contributes net benefits to other livelihoods at the local and global levels and in the long and short term.[43]

Jonathan Davies and Richard Bennett (2007) framed out the definition of sustainable livelihood as the key aspect is the ability of individual or household to cope with or recover from shocks or uncertainties posed by disaster or other extreme events. In this regard, individuals or households who are not able to cope with short-term change (i.e. temporary adjustment or coping) or adopt with long term changes (i.e. adaptation) in livelihood strategies are certainly vulnerable and unlikely to accomplish livelihood security.[44]

DFID (2000) made an integrated framework incorporating vulnerability, access to assets/capitals and livelihood outcomes and recovery has been developed by UK Department for International Development. The DFID framework emphasizes on the range of assets (i.e. natural, physical, human, financial and social), access to and ownership of these assets that make the security of livelihood. The framework puts people on the centre of development and aims to assist stakeholders with different point of view to employ in structured and coherent debate about various factors; their relative significance and the way of interaction that affect livelihood. The major elements of the framework include vulnerability context, livelihood assets, transformation structure and process, livelihood strategies and livelihood outcomes. The assets that are discussed in sustainable livelihood framework explained as 1) Physical Capital, 2) Natural Capital, 3) Financial Capital, 5) Human Capital and 6) Social Capital. [45]

Lee Bosher, Edmund Penning-Rowsell and Sue Tapsell (2007) argued that access to key resources can help in reducing vulnerability of people in large scale disaster as well as small scale crisis events. Findings suggest that caste is key determinant factor in hazard-

---

[43] Robert Chambers and Gordon Conway, *Sustainable Rural Livelihoods: Practical Concepts for the 21st Century*. (UK: Institute of Development Studies, 1992), 15.

[44] Jonathan Davies and Richard Bennett, "Livelihood Adaptation to Risk: Constraints and Opportunities for Pastoral Development in Ethiopia's Afar Region," *The Journal of Development Studies* 43, no. 3 (2007): 490-511.

[45] DFID 2000, Partnership with the private sector, Department for International Development, available at www.dfid.gov.uk/public/working/buspart on April 30, 2016.

prone vulnerable coastal communities in many regions like Andhra Pradesh, India. Lower caste people are more vulnerable because of limited assets and lack of access to public resources and lack of opportunity to reduce vulnerability. However, authors found that lower caste can utilize their informal social network to boost their resilience against disaster. [46]

Edward H. Allison and Frank Ellis (2001) applied that sustainable livelihood framework to understand the strategies adopted by artisanal fisher folk due to the fluctuation of fisheries resources. Findings through application of livelihood approach suggest that many aspects of the conventional fisheries management may be wrong, inappropriate and unnecessary. Diversifying livelihood and geographical mobility could be helpful for resource conservation and generating income as well; and that need policy support rather than unnecessary restrictions. Authors argued that livelihood analysis further expands the scope for making policy and management more supportive (by providing adaptable and flexible income earning strategies, resilient resource management, improving skill, knowledge and social capital) to fisher group in low income countries to find way out of poverty through their livelihood activities.[47]

Anthony Bebbington (1999) developed a framework for analyzing sustainability of rural livelihoods. Author argued that livelihood needs to be considered in terms of people's access to different types of assets; transforming assets to build livelihood; expanding asset base through building relationship with other actors; and the way in which people are able to enhance their capability. However, author gave more emphasis on social capital as an asset, by which people able to expand their access to resources and other actors as well.[48]

Michael R. Carter, Peter D. Little, Tewodaj Mogues, and Workneh Negatu (2007) analyzed that assets dynamics in Ethiopia and Honduras while facing drought, hurricane and other environmental shocks. Authors tried to answer the long term effects of such shocks on household as well as their livelihood. Besides, they tried to find out what circumstances push household into poverty trap, where recovery may not be possible without external

[46] Lee Bosher, Edmund Penning-Rowsell and Sue Tapsell, "Resource Accessibility and Vulnerability in Andhra Pradesh: Caste and Non-Caste Influences," *Development and Change* 38, no. 4 (2007): 615-640.

[47] Edward H. Allison and Frank Ellis, "The Livelihoods Approach and Management of Small-Scale Fisheries," *Marine Policy* 25, no. 5 (2001): 377-388.

[48] Anthony Bebbington, "Capitals And Capabilities: A Framework For Analyzing Peasant Viability, Rural Livelihoods And Poverty," *World Development* 27, no. 12 (1999): 2021-2044.

assistances. They argued that poorest households suffer most due to such shocks adopting coping strategies which might be costly in short and long term perspectives.[49]

Lisa Schipper and Mark Pelling (2006) explored that People develop coping strategies to deal with climate variability as with other shocks or stresses. These include building social networks as forms of insurance, traditional forecasting in order to be prepared for climatic changes and indigenous means of protecting assets. However, the poor's range of coping strategies is naturally more restricted by their lack of assets and by the other stresses on their livelihoods. These stresses are increasing following a number of trends such as increasing prevalence of conflict, globalization and environmental degradation.[50]

David Sanderson (2000) opined that livelihood thinking comes out mostly from rural natural resources. Yet, a livelihoods perspective finds remarkable character in understanding the complexities of urban poverty and in linking poverty with disasters. As the World Bank's Disaster Management Facility states, disaster mitigation needs to be mainstreamed into development practice. Livelihoods approaches to rural poverty problems provide a way of seeing vulnerability to shocks and stresses as an integral part of the development picture. At the same time as livelihoods programming is at a comparatively early stage of development, and has a rurally-focused origin, it appears that it has much to offer in understanding the dynamics of rural poverty. Such approaches place the vulnerability at the centre of thinking and, in so doing, aim to make environment for dwelling by the poor.[51]

Moreover, relevant literatures necessary for different chapters or particular section(s) of a chapter on respective issues related to the present study are also discussed wherever necessary. These are the few reviews for building conceptual framework of this study.

[49] Michael R. Carter, Peter D. Little, Tewodaj Mogues and Workneh Negatu, "Poverty Traps and Natural Disasters in Ethiopia and Honduras," *World Development* 35, no. 5 (2007): 835-856.

[50] Lisa Schipper and Mark Pelling, "Disaster Risk, Climate Change and International Development: Scope for, and Challenges to, Integration," *Disasters* 30, no. 1 (2006): 19-38.

[51] David Sanderson, "Cities, Disasters and Livelihoods," *Environment and Urbanization* 12, no. 2 (2000): 93-102.

Chapter Three
Research Methodology

3.1 Introduction

This study turns around the broad questions of what are the livelihood strategies including coping and adaptation behaviors against the potential impact of climate change induced sea level rise of coastal communities of Bangladesh. How such strategies varies from one area to another, one household to another, and what are the underlying factors influence such variations. The theoretical conceptualization of the issues that livelihood strategies, coping behavior in response to hazard varies over time and space due to multiple factors, and consequently household achieve differential livelihood security outcomes. Therefore, the present study has adopted an integrated approach combining individual, community and intuitional factors to understand this complex issue of livelihood security considering the disaster situation regarding sea level rise at coastal Bangladesh setting. A mixed approach of exploratory and explanatory research has been undertaken to achieve the broad objective of the present study. The following section provides a brief overview of the research design and methodology of this study.

3.2 Nature of the Study

There are two basic approaches in conducting any research which are quantitative approach and qualitative approach. Quantitative research is a more logical and data led-approach which provides an assessment of what people think from a statistical and numerical point of view. In the present study, mainly quantitative approach was used based on primary data collected from household level. This approach usually involves collecting and converting data into numerical form so that calculation can be made to draw conclusion. It also refers to the systematic empirical investigation of any phenomena using mathematical, statistical or computational techniques. Simultaneously, qualitative approach was also used. This is why mixed approach was followed to make the research meaningful.

3.3 Sources of Data

The data have been collected from both primary and secondary sources. Relevant and available secondary data has been taken from different sources for this study like Intergovernmental Panel on Climate Change (IPCC), National Adaptation Programme of

Action (NAPA) and Bangladesh Climate Change Strategy and Action Plan Documents of Bangladesh Government (MoEF) etc. The statistical information has been gathered from Bangladesh Bureau of Statistics (BBS) and Climate Change Cell (CCC), Bangladesh and this information has been reviewed to gather information. Internet sources such as online articles and journals have been selected to assemble related data and information. Primary data for the study have been collected by questionnaire survey with local people, key informant interviews and focus group discussions. The sample has been taken from three coastal zones. Coastal population who are most vulnerable (residing in the exposed coast part) in the coastline area were the main respondents for the study.

3.4 Sampling Techniques

Sampling techniques include selection of study area, types of respondent, sample distribution for the study.

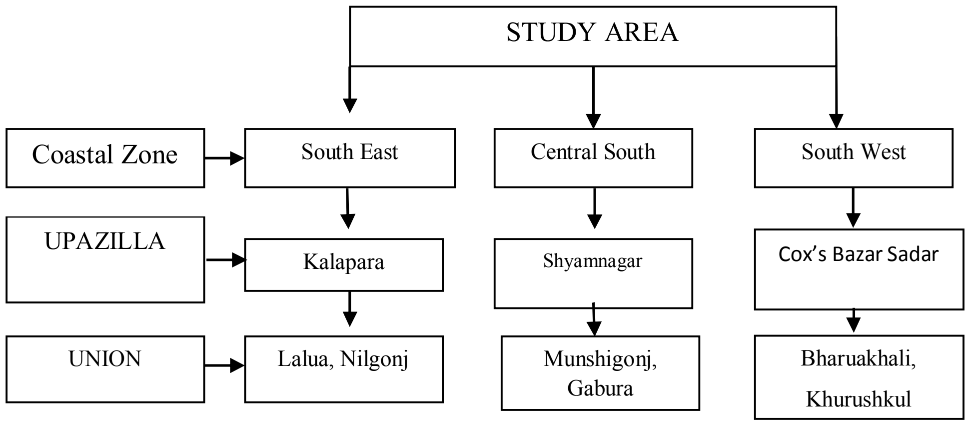
3.4.1 Selection of Study Area

The coastal zone of Bangladesh is divided into two main parts as interior coast and exposed coast. Exposed coast part of Southern Bangladesh is extremely vulnerable to sea level rise. The whole coastal area of Bangladesh can be divided into three major parts as South-east zone, Central south zone and South-west zone. Three upazillas have been taken by lottery method of simple random sampling (SRS) without replacement from exposed coast part of these three zones. Again two unions from each selected upazila have been taken by using the same method. Then expected respondents have been selected on the basis of proportionate purposive sampling from the total households of those unions for questionnaire survey. Head of the household had been the respondent. 5% respondents of each union had been kept proportionally as reserve sample to fill up the gap of missing sample.

The key consideration for selection the exposed coast of the coastal area for the study are were

- Zone of multiple hazards
- Prone to SLR and its associated exposures
- Nearer to sea
- Fragile coastal characteristics in regards to diversity of occupation

Figure 3.1: Selection Procedure of Study Area.



Developed by Researcher

Figure 3.2: Location Map of the Study Area in Bangladesh

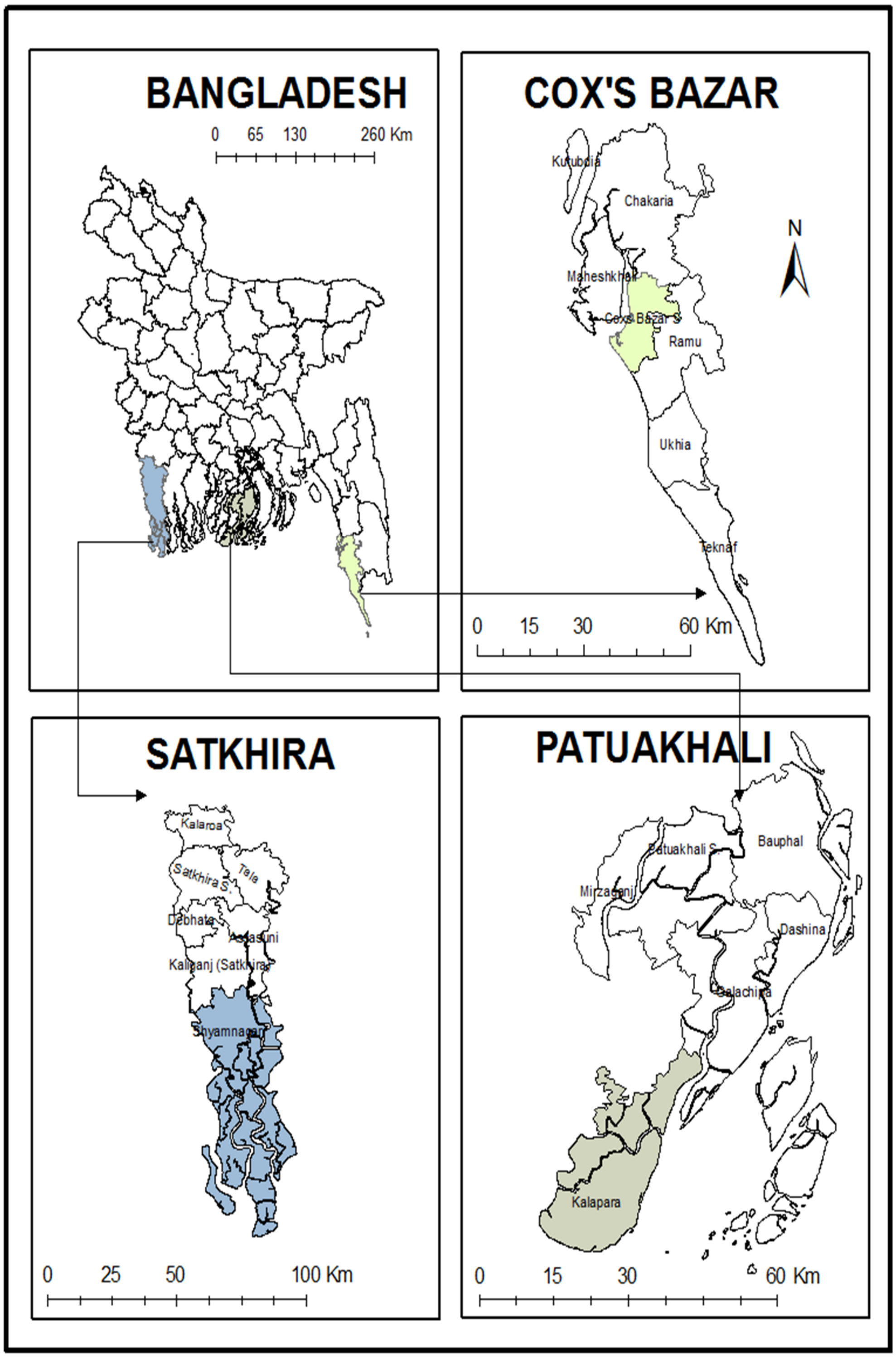


Figure 3.3: Location Map of the Study Area in Bangladesh (Shymnagar Upazila)

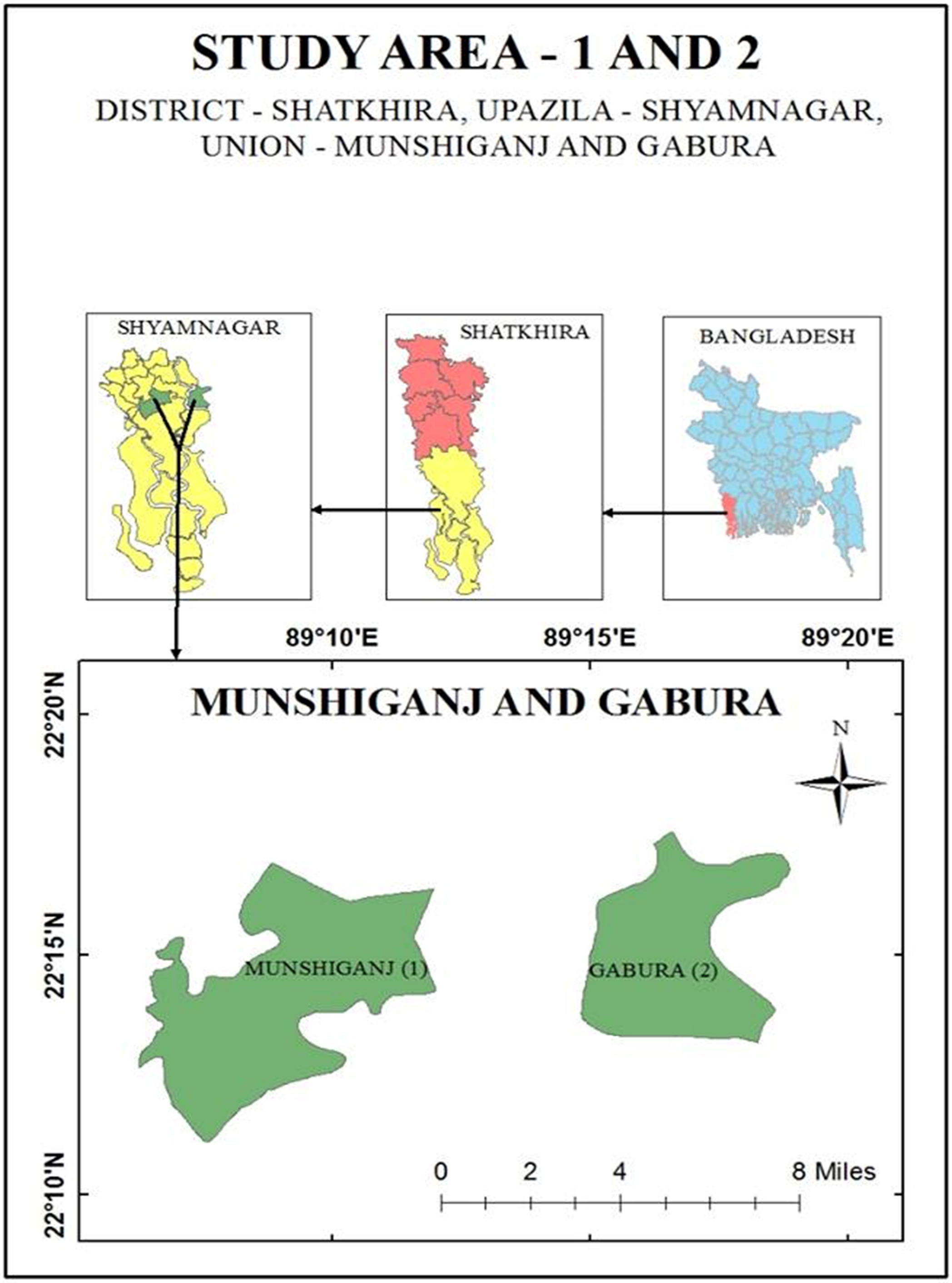


Figure 3.4: Location Map of the Study Area in Bangladesh (Kalapara Upazila)

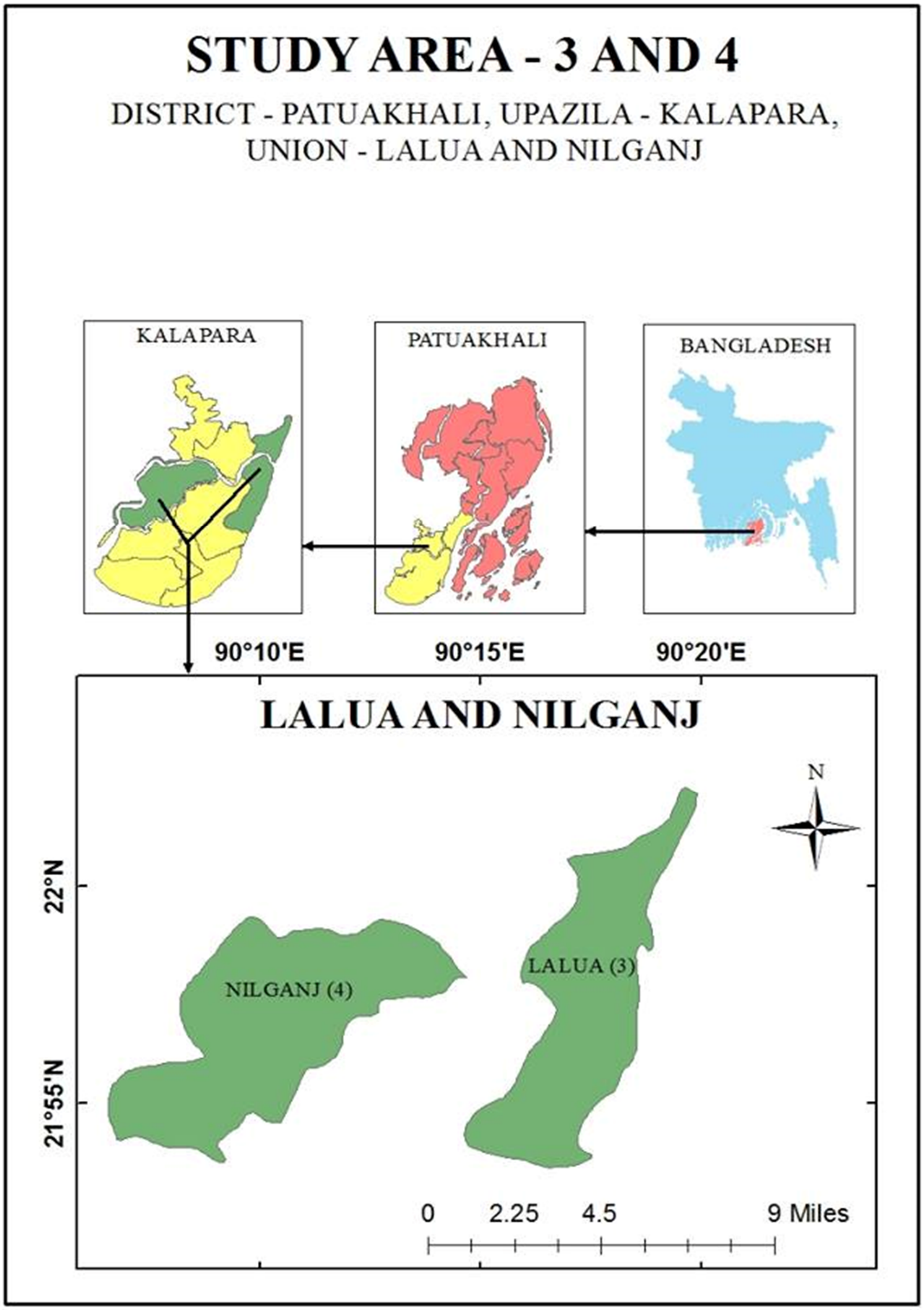
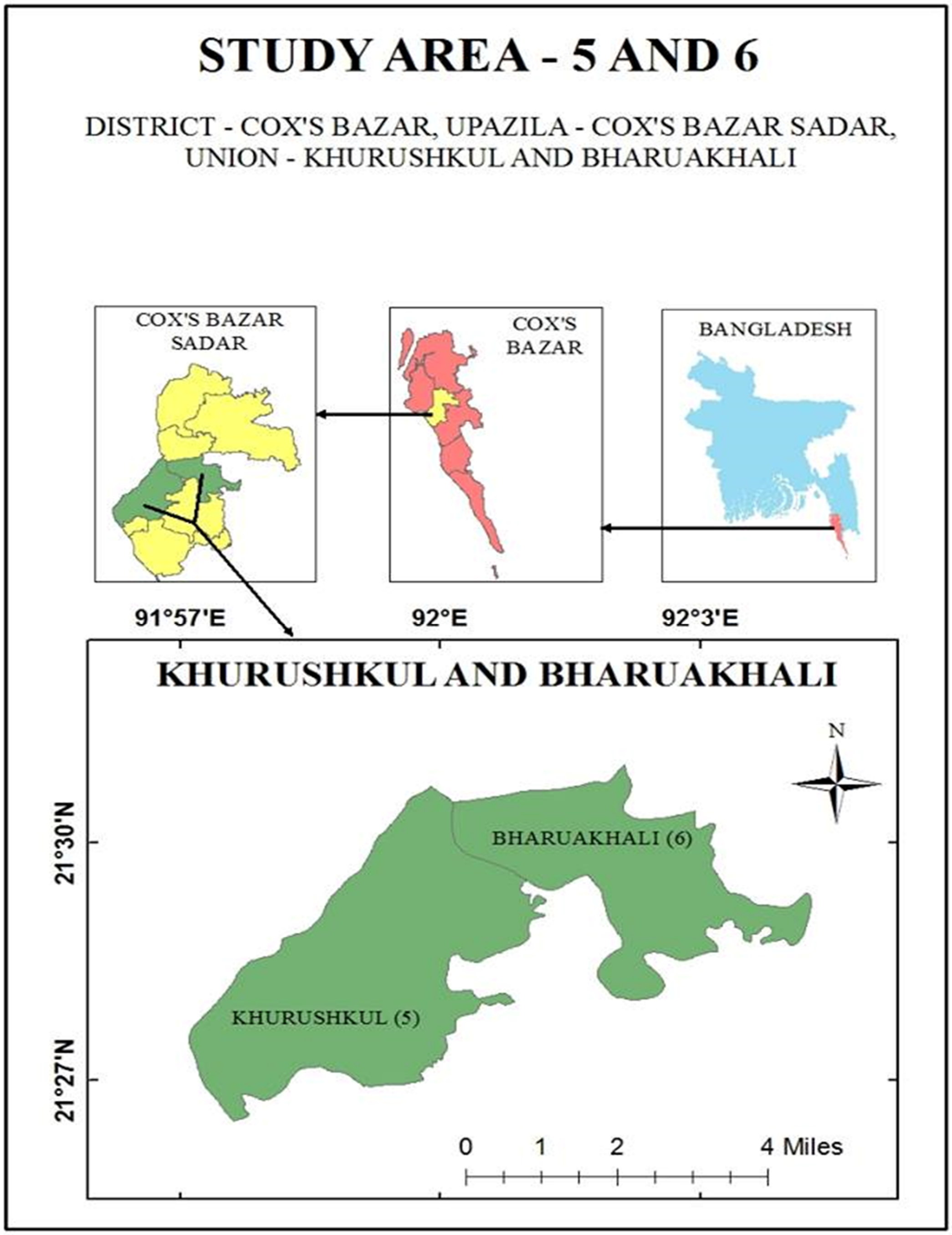


Figure 3.5: Location Map of the Study Area in Bangladesh (Cox's Bazar Sadar Upazila)



3.4.2 Types of Respondents

a. Coastal Zone Population.

b. Organizational Personnel

c. Experts of the Issue.

3.5 Sample Distribution

Table 3.1: For determining sample size, demographic scenario of the study area is required which is as under

Name of Coastal zone (Exposed)	Total No of Upazilla	Selected Upazila by SRS (Lottery method)		Total No of union of selected upazila	Selected Unions by SRS (Lottery method)		Total Household Of the selected union	Weight	Number of Households	Reserve sample (5%)
		No	Name		No	Name				
Central South Zone	21	1	Kalapara	12	2	Lalua	5,170	(5,170/34,337) =.15	(380x.15)=57	3
						Nilgonj	4,311	(4,311/34,337) =.13	(380x.13)=49	3
South West Zone	9	1	Shyamnagar	12	2	Munshigonj	6,600	(6,600/34,337)= .19	(380x.19)=72	4
						Gabura	6,483	(6,483/34,337) =.19	(380x.19)=72	4
South East Zone	18	1	Cox's Bazar Sadar	10	2	Bharuakhali	4,050	(4,050/34,337)=.12	(380x.12)=46	2
						Khurushkul	7,723	(7,723/34,337) =.22	(380x.22)=84	4
Total	48	3		34	6		34,337	1.00	380	20

BBS, 2011[1]

[1] Bangladesh Bureau of Statistics, *Community Series: Patuakhali, Satkhira, Cox's Bazar*. Bangladesh Bureau of Statistics, Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh (Dhaka: November 2014).

For determining sample size from finite population the following well known statistical formula has been used.[1]

$$n = \frac{z^2.p.q.N}{e^2(N-1)+z^2.p.q}$$

$$= \frac{(1.96)^2 \times 0.5 \times 0.5 \times 34337}{(0.05)^2(34337-1)+(1.96)^2 \times 0.5 \times 0.5}$$

$$= \frac{32977}{86.80}$$

=379.92

=380

Source: C.R Kothari, Research Methodology: Methods and Techniques (2nd Ed.), pp.179.

Here,

n = Sample size

N = Total number households

Z = Confidence level (at 95% probability=1.96)

P = estimated population proportion (0.5 this maximizes the sample size)

q = 1-p

e = error limit of 5% (0.05)

Table 3.2: Organizational Personnel

From NGOs (Two personnel from each upazila)	2x3=6
From GOs (Two personnel from each upazila)	2x3=6
Total	12

Table 3.3: Experts of Climate Change Induced Sea Level Rise

Category	NOs
University professor	4
Renown researcher in the field	2
Environmentalist	2
Total	8

[1] Chakravanti Rajagopalachari Kothari, *Research Methodology: Methods and Techniques*, (New Age International: 2004), 179.

Table 3.4: Summary Table

Type of respondents	Number
a) Coastal Zone Population	380
b) Organizational Personnel	12
c) Experts of the Issue	8
Total	400

3.6 Data Collection Techniques

The study is mainly based on primary data and information; and data were collected through standardized structured questionnaire at household level by face to face interview. Beside, few data were collected from key informants as well. In addition, observation and focus group discussions were also conducted to get acquainted and gather additional and supplementary information on sea level rise, its impact on people's regular livelihood activities, coping (adaptation) strategies, and available government and non-government support services for disaster risk reduction, rehabilitation, and various livelihood security outcomes.

3.6.1 Reconnaissance Survey

A reconnaissance survey was conducted in all six unions to collect general information, conceptualize the overall practical situation and obtain background information, get acquainted with the livelihood system of various communities of study areas for selection purpose and designing sample size before starting the standardized questionnaire survey and tune the research plan.

3.6.2 Semi-structured Interview with Key Informants

Semi-structured in depth interview was conducted with people of six selected unions which includes discussion on different issues related to impact of sea level rise on people's economic, social and health condition, damage of local infrastructure, degradation of water quality, soil fertility, coping strategy and government and non-government support services, and livelihood security outcomes and so on. Following this process factors influence people's vulnerability to SLR and aggravate disaster impacts, and institutional process and organizational structures were also outlined. Besides, interviews were conducted with officials of different government and non-government organizations. However, the aim of key informant interview was to gather information on their services, knowing historical background of the community including physical, socio-cultural and socio-economic conditions; people's survival strategies and indigenous coping strategies, and livelihood outcomes etc.

3.6.3 Questionnaire Survey

A survey was conducted at household level through face-to-face interviews by using a standardized structured questionnaire. To collect primary data from SLR affected households, a coordination schema was prepared and a standard structured questionnaire was developed. To ensure the reliability of data, questionnaire was pre-tested in six study unions and necessary modifications were made before conducting final survey.

3.6.4 Field Observation

A field observation was carried out during household survey period with analytical and scientific mind. This helped to understand the current physical condition of the study area, drainage system, road network, settlement pattern, economic activities and livelihood strategies and assets of various households. Observation sheet was used to record the above-mentioned parameters. Photographs were also taken to compare different situations of different communities.

3.6.5 Focus Group Discussion

Total six focus group discussions (FGD) were done. Members were representing from all major livelihood groups in each FGD. The number of member of participants was 12 in each group. It was moderated by the researcher and three field assistants. FGD helped in reviewing the data already gathered at the field level, to fill up the gaps of the information provided by the respondents and understand the related issues of the study.

3.7 Data Analysis Process

After completion of data collection through different techniques the data have been analyzed using the Statistical Package for the Social Sciences (SPSS). Descriptive statistics such as frequency distribution, percentage, mean, median, mode, standard deviation etc. and different graphical presentations such as pie chart, bar diagram etc. were also used for analyzing the collected data. Correlation and Chi-square test have been used to identify the association between the variables. GIS has also been used for different cartographic purpose.

3.7.1 Quantitative Analysis

Descriptive Statistics

Different descriptive statistical techniques such as frequency, percentage, mean, standard deviation were applied to analyze data in terms of general information such as demographic profile, socio-economic condition (for example income level, education, occupation, land holding size) and amount of damage etc. Various diagrams, charts and graphs were used for graphic presentation of data.

Analytical Statistics

ANOVA-test

Analysis of Variance (ANOVA) was applied to test differences among variables such as income, land holding size, intensity of impacts, degree of satisfaction on different issues, coping strategies and various livelihood assets and livelihood security indicators etc. among six different unions.

Chi-square test

Chi-square test was applied to find out similarities and differences of respondents among the unions or within the groups in terms of livelihood, gender, education level, occupation, income type, income level, housing type, food supply, and supply of drinking water, variations in coping, livelihood outcomes and other relevant categorical data. Besides, government and non-government support services and their variations according to social class were measured through Chi-square tests.

Regression

In the coastal zone of Bangladesh people face different disasters over time with different intensity which tremendously affect the food security of low income group. To find out the potential impact of SLR on food security a linear regression technique was applied to identify the influence of socio- economic variables, livelihood assets and different coping measures on the amount of caloric intake per capita per day. Food availability and per capita calorie consumption depends on various factors such as income, occupation, gender, adopted coping measures during crisis, various livelihood assets and other relevant variables. To run the regression model correlation between different variables are also considered. Independent variables, which were significant at 95 and 99 percent of confidence level in correlation analysis, were used for running regression models. Disaster related losses and post disaster food availability are generally related with livelihood of inhabitants, technology, and accumulations of capitals or resources in a given society. In addition to these, food security of a household could be associated with a number of socio-economic and demographic variables. Therefore, linear regression model was hypothesized in following way.

> Y_1 (Per capita calorie per day) = f (Physical Capital, Financial capital, Natural capital, Human Capital, Social capital; selected socio-economic and demographic variables).

3.7.2 Qualitative Analysis

The qualitative information obtained from open ended questions, group discussions, informal discussions, key informants interviews, field observations were used to substantiate quantitative data. Information collected from secondary sources related to policy, institutional, social and cultural aspects were analyzed in a consistent and coherent way to develop logical arguments and draw conclusions. The qualitative data analysis was used to substantiate quantitative analysis on key indicators of social scaling and other related issues of the study in respective chapters.

Weighted Average Index (WAI)

The WAI was applied in this study to measure various types of social scaling such as assessing livelihood capitals, extent of effectiveness of coping strategies, prioritizing the organizational help for reducing the intensity of potential impact of sea level rise and storm surge; and satisfaction on governmental and non-governmental organizations support services and so on. These indices were designed based on social scaling technique (five point Likert scale) to address different issues wherever necessary. Few examples are presented below

Ability to Work in Adverse Condition

Very High (1)	High (2)	Moderate (3)	Low (4)	None (5)
1.0	0.75	0.50	0.25	0.00

Participated Disaster Related or Other Training Programs

More than 4 times (1)	3 times (2)	2 Times (3)	1 Times (4)	None (5)
1.0	0.75	0.50	0.25	0.00

Representative of Groups or Expressing Idea in Group Meetings or Helping other to Solve Problems or Facilitating Community Activities

Always (1)	Usually(2)	Very Often (3)	Often (4)	Never (5)
1.0	0.75	0.50	0.25	0.00

Access to Common Natural Resources

Very High (1)	High (2)	Moderate (3)	Low (4)	None (5)
1.0	0.75	0.50	0.25	0.00

Access to Physical Resources

Very Good (1)	Good (2)	Moderate (3)	Poor (4)	Very Poor (5)
1.0	0.75	0.50	0.25	0.00

Access to Mass Media, Government, and Non-government Organizations

> 3 days in a	2-3 days in a	once in a month	< once in a	No Access
1.0	0.75	0.50	0.25	0.00

Listening and following climate forecasting

Always (1)	Very Often (2)	Sometimes (3)	Rarely (4)	Never (5)
1.0	0.75	0.50	0.25	0.00

Extent of effectiveness of coping measures

Highly Effective (1)	Effective (2)	Sometimes Effective (3)	Rarely Effective (4)	Not Effective (5)
1.0	0.75	0.50	0.25	0.00

Needs assessment and prioritizing the organizational help regarding potential impact of sea level rise

Very High (1)	High (2)	Moderate (3)	Low (4)	Very Low (5)
1.0	0.8	0.6	0.4	0.2

The score of each item was calculated by using the following formula:

$$WMI = [\{fVH\ (1.0) + fH\ (0.8) + fM\ (0.6) + fL\ (0.4) + fVL\ (0.2)\}/N]$$

Where, WAI = Weighted Average Index

f(VH) = Frequency of (1)

f(H) = Frequency of (2)

f(M) = Frequency of (3)

f(L) = Frequency of (4)

f(VL) = Frequency of (5)and

N = Total number of observations

Satisfaction on governmental and non-governmental organization's support services

Strongly Satisfied	Satisfied	Neutral	Dissatisfied	Strongly Dissatisfied
1.0	0.8	0.6	0.4	0.2

Strongly Satisfied	Satisfied	Neutral	Dissatisfied	Strongly Dissatisfied
1.0	0.8	0.6	0.4	0.2

The score of this item was calculated by the following formula:

$$WMI = [\{fSS\ (1.0) + fS\ (0.8) + fN\ (0.6) + fD\ (0.4) + fSD\ (0.2)\}/N]$$

Where WAI = Weighted Average Index,

f (SS) = Frequency of Strongly Satisfied

f (S) = Frequency of Satisfied

f (N) = Frequency of Neutral

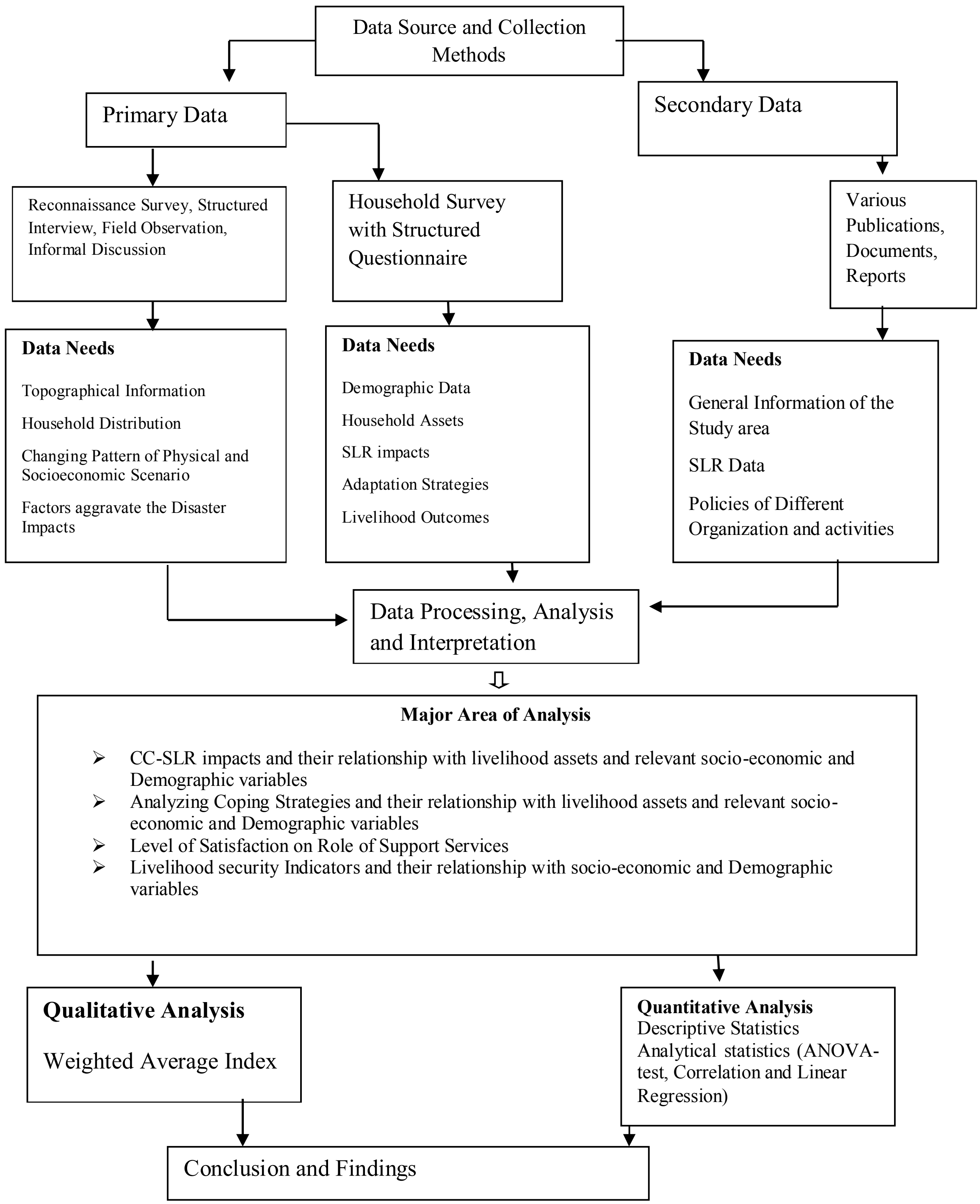
f (DS) = Frequency of Dissatisfied

f (SD) = Frequency of Strongly Dissatisfied and

N = Total number of observations

Apart from the above examples of data analysis techniques, detail procedure of various tools and techniques, formula and measuring procedures employed in the present study are also discussed in the respective chapters and sections. However, above are the few examples of major data analysis techniques. Figure 3.6 presents overall research design, data collection methods and analysis techniques for this study.

Figure 3.6: Research Design, Data Collection Methods and Analysis



3.8 Reliability and Validity of Data

The data reviewed in this research bears a close relationship with issues of climate change. The statistics collected from different governmental and nongovernmental organizations clearly show the way that the climate has changed over the last decades of time in the selected coastal region of Bangladesh and how these changes have affected the lives and livelihoods of those communities who live in the region. In order to understand local people's experiences during my stay in the study area, six focus-group based semi-structured interviews were conducted in the field, as well as expert's interview with GOs and NGOs employed in different sectors. The expert's interviews were recorded with the permission of the interviewee.

The participants of those focus-group interview sessions were seventy two in number and the interview session took place in different places of six selected localities. I chose a house at Munshigonj where all the interviewees were gathered, while at Gabura the interview session took place another house. These women were engaged in household works and agreed to take part this interview session. The other four interview sessions took place at different houses. Gabura is an island, very close to the Sundarbans and severely devastated by the cyclone Aila in 2009.

My key informants, Samad Ali and Abdur Rahman played a vital role in organizing people for these interview sessions at Gabura. Because of their familiarity with the local people and customs, all the participants took part voluntarily. The participants were of different ages and from different religions. Some of the participants were moderately rich, some of them from middle class, and some of them came from the marginal communities, and have no permanent shelter or secured job. All the interviews took approximately 20 to 30 minutes. The interviews were conducted in the afternoon, when most of the men come back from their work and have free time for little conversation.

The expert interview with the famous Bangladeshi environmentalist and the chairman of Climate Action Network- South Asia (CANSA) and the Executive Director of Bangladesh Centre for Advance Studies (BCAS) Dr. A Atiq Rahman, took place on March 14th, 2017 at 2.30 PM in his office at Gulshan in Dhaka. The interview lasted for about 30 minutes. The interview was recorded under the permission of the interviewee, and the researcher informed him that the interview will only be used in this PhD thesis, not for other purpose.

3.9 Ethical Considerations

As a researcher of Institute of Bangladesh Studies, University of Rajshahi, the whole thesis work has been done under the guidelines of the university. In field visit and taking interviews for the thesis, the researcher has introduced himself as a student of the PhD program of Institute of Bangladesh Studies, University of Rajshahi. The interviews were carried out in a way where every respondent was well-informed by me about the objectives of the interview before the interview session. The researcher also took some photographs of the field with the permission of local people.

Chapter Four
Study Area and Respondents Profile

4.1 Introduction

Physical Environment, exposure to disasters, inhabitants' socio-economic condition, cultural and social structures are needed to consider for livelihood securities of an area. Such factors have significant influence on adoption of coping behaviors in response to disasters for achieving livelihood security.[1] To provide the context under which current livelihood strategies (including coping strategies) have evolved, this chapter briefly provides geophysical and socio-economic environment of study areas following a concise introduction of the impacts of sea level rise. First section describes geophysical conditions following socio-economic profile in the second section and finally comparative locational assessment of the study area.

4.2 Geophysical Setting

4.2.1 Area and Location

Kalapara Upazila's area is 483.08 sq. km, located in between 21°48' and 22°05' north latitudes and in between 90°05' and 90°20' east longitudes. It is bounded by Amtali upazila on the north, Bay of Bengal on the south, Rabnabad Channel and Galachipa upazila on the east, Amtali upazila on the west. The major rivers are the Andharmanik, Nilganj and Dhankhali.[2]

Shyamnagar is located at 22.3306°N 89.1028°E. It has 46,592 households and a total area of 1968.24 km². Shyamnagar Upazila is bordered by Kaliganj (Satkhira) and Assasuni upazilas to the north, the Sundarbans and Bay of Bengal to the south, Koyra and Assasuni upazilas to the east and Hingalganj (community development block) in North 24 Parganas district in the Indian state of West Bengal to the west. The main rivers here are Raymangal, Kalindi, Kobadak, Kholpetua, Arpangachhia, Malancha, Hariabhanga and Chuna. South Talpatti Island at the estuary of the Hariabhanga is notable.[3]

---

[1] S. K. Paul and J. K. Routray, "Flood Proneness and Coping Strategies: The Experiences of Two Villages in Bangladesh," *Disasters* 34. No.2 (2010): 489.

[2] Bangladesh Bureau of Statistics, *Community Series: Patuakhali,* Bangladesh Bureau of Statistics, Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh (Dhaka: November 2014), 27.

[3] Bangladesh Bureau of Statistics, *Community Series: Satkhira,* Bangladesh Bureau of Statistics, Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh (Dhaka: November 2014).

Cox's Bazar Sadar Upazila's area is 228.23 sq. km, located in between 21°24' and 21°36' north latitudes and in between 91°59' and 92°08' east longitudes. It is bounded by Chakaria upazila on the north, Bay of Bengal and Ramu upazila on the south, Ramu upazila on the east, Maheshkhali upazila, Maheshkhali channel and Bay of Bengal on the west. The Matamuhuri, Bakkhali, Reju Khal, Naf, Maheshkhali channel and Kutubdia channel are the main rivers. Main forests areas are Phulchhari Range, Bhumaria-ghona Range, Meher-ghona Range and Bak Khali Range.[4]

4.2.2 Demographics Description

As of the 2011 Bangladesh census, Kalapara has a population of 174921. Males constitute 50.89% of the population, and females 49.11%. This Upazila's eighteen up population is 82394. Kalapara has an average literacy rate of 34.9% (7+ years), and the national average of 32.4% literate.

Total Population of Cox's Bazar is 348075.The number of male population is 186151 and female is 161924. According to census of 2011 the number of Muslim is 314563, Hindu 27039, Buddhist 199, Christian 6244 and others 30.

Total Population of Shymnagar upazilla is 313781. The number of male population is 160294 and female 153487. Muslim 243257, Hindu 70151, Buddhist 56, Christian 20 and others 297 according to religious classification. Indigenous communities such as Munda, Bhabene, Charal and Kaiborta belong to this upazila. The population density is 1024 per km². Literacy rate among the town people is 37.3%.

4.2.3 Sociopolitical Settings

Kalapara

The Rakhain tribe of Bangladesh first settled in this upazila. A section of the people belonging to the Buddhist Rakhain tribe of Arakan came to this upazila in quest of better living and first settled at Khepupara and Kuakata. Tradition goes that the Rakhains on excavating wells traced fresh water in the area and thereby settled there. Important installations and tourist spots kuakata, the second largest tourist centre of the country, is

[4] Bangladesh Bureau of Statistics, *Community Series: Cox's Bazar*. Bangladesh Bureau of Statistics, Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh (Dhaka: November 2014).

located on the southern extremity of the upazila. Both sun rise and sun set can be viewed from the 18 Km long Kuakata sea beach. The average breadth of the beach is about 3 to 3.5 km. The Shutki (dried fish) Palli is located 7 km on the west of Kuakata. During the winter season verities of sea fishes are collected at Shutki Palli and are processed there. Dry fish is exported in different parts of the country from this Palli. Besides, to attract the tourists there are Sea Fish Museum, Bura Gauranga Sea Chanel, Kuakata Sima Buddhist Bihara, statue of Buddha, Rakhain Palli, Narikel Bithi, Jhouban (tamarisk trees), Fatrar Char (mangrove), Gangamatir Char, Rash Mela, Lembur Char, etc. Main sources of income achieved from Agriculture 57.23%, non-agricultural laborer 4.80%, industry 0.43%, commerce 13.50%, transport and communication 2.14%, service 4.56%, construction 1.36%, religious service 0.21%, rent and remittance 0.20% and others 15.57%.[5]

Shyamnagar

Shyamnagar thana was turned into an upazila in 1982. It consists of 12 union parishads, 127 mouzas and 216 villages. The average literacy in the entire upazila is 28.1%, comprising 38% among males and 17.4% among females. Main sources of income achieved from Agriculture 64.98%, non-agricultural laborer 6.02%, industry 0.61%, commerce 14.60%, transport and communication 1.58%, service 3.53%, construction 0.94%, religious service 0.16%, rent and remittance 0.20% and others 7.34%.

Cox's Bazar

The longest sea beach of the world is located at Cox's Bazar. The green surroundings with the mangrove forests on the beach are also notable. Most of the areas of the upazila are covered with hills and tilas. Since Cox's Bazar is a great tourist resort various establishments have developed here including several hotels of which some hotels have been established on government initiatives. Jhinuk Market and the Burmese Market are the two tourists attractive markets where luxury goods coming from China, Burma, Thailand through the border.

[5] Bangladesh Bureau of Statistics, *Community Series: Patuakhali,* Bangladesh Bureau of Statistics, Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh (Dhaka: November 2014), 27.

4.3 Climate of the Study Area

Cox's Bazar Sadar upazila often becomes victim to sea storm, tidal bore, hurricane and cyclone. Cox's Bazar is typically similar to the rest of the country. However, it characterized by the location in the coastal region. The annual average temperature in here remains at approximately highest 34.8 °C and lowest 16.1°C. The average amount rainfall is at 4,285 mm.[6]

The average temperature for the year in Shymnagar upazilla is 77.0°F (25°C). The warmest month, on average, is May with an average temperature of 86.0°F (30°C). The coolest month on average is January, with an average temperature of 66.0°F (18.9°C). The average amount of precipitation for the year in Satkhira is 66.5" (1689.1 mm). The month with the most precipitation on average is July with 13.9" (353.1 mm) of precipitation. The month with the least precipitation on average is January with an average of 0.3" (7.6 mm). In terms of precipitation, there are an average of 98.0 days of rain, with the most rain occurring in July with 19.0 days of rain, and the least rain occurring in December with 1.0 days of rain. The physical development processes along the coast are influenced by a multitude of factors, comprising wave motions, micro and macro-tidal cycles and long shore currents typical to the coastal tract. The shore currents vary greatly along with the monsoon. These are also affected by cyclonic action.[7]

The climate is tropical in Kalapara. Rainfall is significant most months of the year, and the short dry season has little effect. The average annual temperature in Kalapara is 25.9 °C. In a year, the average rainfall is 2647 mm. The area is composed of some small chars or islands. The region having been close to the sea, frequently falls victim to tornado and tidal bore. The precipitation varies 606 mm between the driest month and the wettest month. Throughout the year, temperatures vary by 10.0 °C.

By analyzing the present mean temperature, near future mean temperature and future mean temperature of Bangladesh and those of the study areas it is found that present

---

[6] Bangladesh Bureau of Statistics, *Community Series: Cox's Bazar,* Bangladesh Bureau of Statistics, Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh (Dhaka: November 2014), 15.

[7] Bangladesh Bureau of Statistics, *Community Series: Satkhira,* Bangladesh Bureau of Statistics, Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh (Dhaka: November 2014), 23.

temperature has shown an increasing trend, but in future the rate of increment will be higher than the present. Further studies are needed to know the future climatological situations of other disaster prone areas of Bangladesh.

The present study indicates that the mean temperature for Bangladesh rises slightly, but during near future and future the mean temperature rises is expected to be much more than the present. The present, near future and future average rainfalls of Bangladesh was observed to fluctuate, but have shown a decreasing trend.

4.4 Profile of Respondents

The population of the study unions mostly depends on natural resources such as farming and fishing in open water for their economic activities. In terms of ethnic composition, household size, labor force, landholding size, occupational devotion and educational attainments, it is found that coastal people live under heterogeneous socio-economic conditions. So, socio-economic diversity considering the socio-economic factors have significant influence on livelihood strategies, adoption of coping strategies to face the adversity posed by climate change induced sea level rise and future livelihood security effects.

4.4.1 Age Structure, Years of Living and Places of Origin of Respondents

Overall age structure of the study shows that average age is 44.24 years and the range of respondent's age is from 26 years to 75 years. Age structure of household heads are classified in to three groups (young < 30 years, active 30-60 years and aged > 60 years) in which more than 93.95% of total respondents fall in the age group of 30 years to 60 years. About 93.1%, 91.7 %, 91.2%, 85.7%, 100% and 100% of respondents fall in the same category in Munshigonj, Gabura, Lalua, Nilgonj, Khurushlkul and Bharuakhali unions respectively. In the age group of below 30 years the portions are 6.9%, 4.2%, 0.0%, 14.3%, 0.0% and 0.0% in respective mentioned unions. Under the age group of more than 60 years the portions are 0.0%, 4.2, 8.8%, 0.0%, 0.0% and 2.1% in the respective mentioned unions. However, this study finds that significant different exists among six unions in terms of respondents' age category (table 4.1), where active age group is higher in Inland unions (Munshigonj, Khurushkul) and aged group is higher in coastal adjacent unions (Lalua).

Table 4.1: Distribution of Household Head by Age

Age Category (Year)		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
<30	n	5	3	0	7	0	0	15
	%	6.9%	4.2%	0.0%	14.3%	0.0%	0.0%	3.9%
30-60	n	67	66	52	42	84	46	357
	%	93.1%	91.7%	91.2%	85.7%	100.0%	100.0%	93.9%
>60	n	0	3	5	0	0	0	8
	%	0.0%	4.2%	8.8%	0.0%	0.0%	0.0%	2.1%
Total	n	72	72	57	49	84	46	380
	%	18.9%	18.9%	15.0%	12.9%	22.1%	12.1%	100.0%
Likelihood ratio		Value= 42.018, df=10, p=.000			Average age= 44.24			

Source: Questionnaire Survey, June-October, 2016

The study finds that most of the respondents are native and have been living for years. The native portions are 73.6%, 22.2%, 21.1%, 73.5%, 92.9% and 21.7% respectively in the unions of Munshigonj, Gabura, Lalua, Nilgonj, Khurushlkul and Bharuakhali. The rest respondents are the settlers from different inland locations of nearby thana or districts.

However, such findings reveal that spatial mobility of population in terms of settling in vulnerable locations to coastal hazards is quite common in coastal Bangladesh. It is a continuous process of human migration in the coast as newly accelerated land provides more resources and livelihood opportunity to disadvantageous people. Hence, most cases resource poor and landless population from inland location use to migrate in inland places with the hope of better livelihoods.

The study also finds that migrated portion is also significant. However, such findings reveal that for the security of livelihood facing different obstacle they are living in the vulnerable coastal area. Hence, most cases resource poor and landless population from inland location use to migrate in low laying vulnerable places with the hope of better livelihoods. This finding is further supported by the age group of settlers, which unveils that household heads in active age group live in the coastline for the opportunities of livelihood securities.

Table 4.2: Place of Origin of Living of Household Head by Unions

Nature of Origin		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Native	n	53	16	12	36	78	10	205
	%	73.6%	22.2%	21.1%	73.5%	92.9%	21.7%	53.9%
Migrated	n	19	56	45	13	6	36	175
	%	26.4%	77.8%	78.9%	26.5%	7.1%	78.3%	46.1%
Total	n	72	72	57	49	84	46	380
	%	18.9%	18.9%	15.0%	12.9%	22.1%	12.1%	100.0%
Pearson Chi-Square	Value=143.112, df=5, p=.000							

Source: Questionnaire Survey, June-October, 2016

4.4.2 Year of Living of Household Head by Unions

The study reveals that most of the respondents have been living in the area for long time i.e. about 61.1% people have been living more than 40 years. Facing hydro-meteorological constraints they are to stay here. Moreover, there are not enough opportunities for them to leave the area. Among the respondents 34.7% have been staying in the area 40 to 60 years. The number is lower in most perilous zone of Nilgonj and Bharuakhali (14.3% and 21.7% respectively). About 2.4 % respondents have been living for less than 20 years. Some of them are migrated for coastal hazard. The rest 1.8% are here for more than 60 years. Most of the populations of this section are natural hazard affected.

Table 4.3: Year of Living of Household Head by Unions

Living Category of Respondents (year)		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
<20	n	1	1	3	4	0	0	9
	%	1.4%	1.4%	5.3%	8.2%	0.0%	0.0%	2.4%
20-40	n	40	39	29	38	50	36	232
	%	55.6%	54.2%	50.9%	77.6%	59.5%	78.3%	61.1%
40-60	n	31	30	20	7	34	10	132
	%	43.1%	41.7%	35.1%	14.3%	40.5%	21.7%	34.7%
>60	N	0	2	5	0	0	0	7
	%	0.0%	2.8%	8.8%	0.0%	0.0%	0.0%	1.8%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Source: Questionnaire Survey, June-October, 2016

4.4.3 Gender of the Household Head and Household Size

Analysis of household head's gender indicates that all the six study unions are male dominated. It reveals that 85.50% of total household heads are male. In case of individual unions 83.3%, 91.7%, 96.5%, 83.7%, 77.4% and 82.6% of household heads are male in Munshigonj, Gabura, Lalua, Nilgonj, Khurushkul and Bharuakhali union respectively (table 4.4). Female headed households are relatively higher in Munshigonj and Khurushkul unions. Seasonal migrant fishermen settled in the low lying Gabura and Lalua during fishing periods and get married with local women. However, while fishing periods are over those migrant fishermen go back to their origin place by abandoning their wives. Similar feature is applied for migrant agriculture worker in Munshigonj, Nilgonj unions as it is mostly agro-based and needs more labors during plantation and harvesting seasons.

Table 4.4: Distribution of Household Head by Gender

Gender of Respondent		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushkul	Bharuakhali	
Male	n	60	66	55	41	65	38	325
	%	83.3%	91.7%	96.5%	83.7%	77.4%	82.6%	85.5%
Female	n	12	6	2	8	19	8	55
	%	16.7%	8.3%	3.5%	16.3%	22.6%	17.4%	14.5%
Total	Total	72	72	57	49	84	46	380
	% of Total	18.9%	18.9%	15.0%	12.9%	22.1%	12.1%	100.0%
Likelihood Ratio	Value= 12.96, df=5 , p=.004							

Source: Questionnaire Survey, June-October, 2016

4.4.4 Household Size of the Respondents

Average household size of the total study area is 4.43. The household size of the study unions are 4.54, 4.41, 4.43, 4.36, 4.30 and 4.56 for Munshigonj, Gabura, Lalua, Nilgonj, Khurushlkul and Bharuakhali respectively. It reveals that average household size is mostly similar in six locations (table 4.5). However, it is slightly higher in two unions such as Munshigonj and Khurushkul unions; and the rest location has lower household size than the mentioned unions and district average.

Table 4.5: Household Size of the Respondents

Household Size (Person)		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
<3	n	11	8	8	8	1	0	36
	%	15.3%	11.1%	14.0%	16.3%	1.2%	0.0%	9.5%
3-5	n	55	64	46	39	64	44	312
	%	76.4%	88.9%	80.7%	79.6%	76.2%	95.7%	82.1%
>5	n	6	0	3	2	19	2	32
	%	8.3%	0.0%	5.3%	4.1%	22.6%	4.3%	8.4%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Average HH Size		4.54	4.41	4.43	4.36	4.30	4.56	4.43

Source: Questionnaire Survey, June-October, 2016

4.4.5 Education

The literacy rates in all the unions are gradually increasing. Among three Upazilas current literacy rate is slightly higher in Kalapara (51.5%) than Cox's Bazar (47.9%) and Shyamnagar (43.9%). It reveals that literacy rate in Kalapara upazila is lower than that country average 53.9% in 2011. Disparity exists between male and female literacy rate in the study upazila, though female literacy rate is also increasing gradually (table 4.6).

Table 4.6: Adult Literacy Rate in Shymnagar, Kalapara and Cox's bazar Sadar upazilla Upazila and Bangladesh

Location	Literacy Rate								
Upazilas and Bangladesh	1991			2001			2011		
	Both Sex	Male	Female	Both Sex	Male	Female	Both Sex	Male	Female
Shymnagar	30.54	39.73	21.00	39.7	47.7	31.3	48.6	53.8	43.9
Kalapara	36.41	42.65	30.05	56.90	58.9	54.7	52.00	52.6	51.5
Cox's Bazar	21.89	28.16	14.90	39.7	44.0	34.7	49.2	54.4	47.9
Bangladesh	32.40	38.90	25.15	45.32	49.56	40.83	56.8	59.8	53.9

Source: Bangladesh Bureau of Statistics, *Statistical Yearbook of Bangladesh 2011*. 31st ed. Bangladesh Bureau of Statistics, Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh (Dhaka: September 2012).

Literacy refers to the ability to write a letter in any language. Considering this definition by Bangladesh Bureau of Statistics, literacy of the household heads are measured in four categories; such as illiterate, can read and write, primary school, and secondary school and higher education. It reveals that majority (36%) of the sampled household heads are illiterate, and it is 35%, 28%, 26%, 21% and 15 % in Gabura, Bharuakhali, Munshigonj, Khurushkul and Nilgonj union respectively. In total of sampled respondents about 40.8% can read and write, 8.4% have primary school level and 5.8% have secondary school and higher level education. Significant difference exists among the villages in terms of literacy, where illiteracy is higher in Lalua, Gabura union followed by Bharuakhali and Nilgonj (table 4.7). Household head can read and write and completed primary school level education is higher in Nilgonj followed by Munshigonj and Khurushkul. In contrary, household's head having secondary school and above level education is higher in Munshigonj union followed by Nearer to sea side location. However, in terms of household head's literacy, sea side location (i.e. Lalua and Gabura) is in more disadvantageous position than interior location (i.e. Munshigonj, Nilgonj) from sea. Reasons could be attributed with non-existence of educational institutions in the union of Gabura and Lalua followed by poor communication network and lack of awareness regarding education among the inhabitants of the unions.

Table 4.7: Education Level of Household Head by Village

Education Status of Respondent		Study Villages						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Illiterate	n	21	35	36	15	26	28	161
	%	29.2%	48.6%	63.2%	30.6%	31.0%	60.9%	42.4%
Can read & write	n	34	31	15	21	43	11	155
	%	47.2%	43.1%	26.3%	42.9%	51.2%	23.9%	40.8%
Primary School	n	8	3	2	9	7	3	32
	%	11.1%	4.2%	3.5%	18.4%	8.3%	6.5%	8.4%
Secondary school	n	9	3	1	4	3	2	22
	%	12.5%	4.2%	1.8%	8.2%	3.6%	4.3%	5.8%
College	n	0	0	3	0	5	2	10
	%	0.0%	0.0%	5.3%	0.0%	6.0%	4.3%	2.6%
Total	n	72	72	57	49	84	46	380
	%	18.9%	18.9%	15.0%	12.9%	22.1%	12.1%	100.0%

Source: Questionnaire Survey, June-October, 2016

4.4.6 Land Ownership

Land ownership of the households is unequally distributed in the study villages. The average land holding size is 0.33 acres for all the unions, while it is 0.29, .21, 0.19, 0.25, 0.90 0.14 acres in Munshigonj, Gabura, Lalua, Nilgonj, Khurushkul and Lalua unions respectively. According to Food and Agricultural Organization land ownership is classified in to three major groups. Household having total land of 0 to 0.05 acres are landless, 0.05 to 1.50 acres are small farmers, and more than 1.50 acres are classified as medium and large farmers.[8] It reveals that landless account for 8.3%, 16.7%, 29.8%, 24.5%, 17.9%, 4.3 % and 16.8 % of Munshigonj, Gabura, Lalua, Nilgonj, Khurushkul and Lalua unions respectively. Highest number of households falls in the small farmer category; 79.2 %, 70.8%, 70.2%, 65.3%, 82.1% and 95.7% of households are small farmer in mentioned unions respectively. Likewise, medium and large farmers account for 12.5% only both for Munshigonj and Gabura unions. Significant difference exists among six unions in terms of land holding size (table 4.8). Average land holding size is much lower in Gabura, Lalua and Bharuakhali than Munshigonj, Nilgonj. Likewise, most uneven land distribution is found in exposed union, where number of landless and medium farmer is higher among the six unions. This unveils that few numbers of respondents having relatively big amount of land, and highly skewed land distribution.

Table 4.8: Landownership Pattern of Households by Unions

Ownership of Land		Study Unions						
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	Total
landless	n	6	12	17	12	15	2	64
	%	8.3%	16.7%	29.8%	24.5%	17.9%	4.3%	16.8%
Small farmer	n	57	51	40	32	69	44	293
	%	79.2%	70.8%	70.2%	65.3%	82.1%	95.7%	77.1%
Medium and Large farmer	n	9	9	0	5	0	0	23
	%	12.5%	12.5%	0.0%	10.2%	0.0%	0.0%	6.1%
Total	n	72	72	57	49	84	46	380
	%	18.9%	18.9%	15.0%	12.9%	22.1%	12.1%	100.0%
Average Land Holding Size		0.29	.21	0.19	0.25	0.90	0.14	0.33

Source: Questionnaire Survey, June-October, 2016

4.4.7 Religion of the Respondents

Religion of a community has influence on livelihood. Some traditional livelihood practices are seen in some specific communities. For example in coastal region of Bangladesh Hindu communities prefer fishing. They have engaged themselves in fishing for decades of time. Their presence is found in almost every fisher group and they believe that livelihood is secured by the fishing profession. Considering the religious portion most of the respondents Muslims (77.1%) than comes Hindu (18.9%), Christian (2.1%) and Buddhist (1.8%).

[8] FAO, Bangladesh: *Country Overview,* retrieved from http:// www.fao.org/ag/agl/swlwpnr/ reports/y_sa/z_bd/ bd.htm #overview (2004) accessed 21July 2016.

Table 4.9: Religion of Household Head by Unions

Study Unions		Religion				Total
		Islam	Hindu	Buddhist	Christian	
Munshigonj	n	48	24	0	0	72
	%	66.7%	33.3%	0.0%	0.0%	100.0%
Gabura	n	62	10	0	0	72
	%	86.1%	13.9%	0.0%	0.0%	100.0%
Lalua	n	43	14	0	0	57
	%	75.4%	24.6%	0.0%	0.0%	100.0%
Nilgonj	n	45	4	0	0	49
	%	91.8%	8.2%	0.0%	0.0%	100.0%
Khurushlkul	n	57	18	7	2	84
	%	67.9%	21.4%	8.3%	2.4%	100.0%
Bharuakhali	n	38	2	0	6	46
	%	82.6%	4.3%	0.0%	13.0%	100.0%
Total	n	293	72	7	8	380
	%	77.1%	18.9%	1.8%	2.1%	100.0%

Source: Questionnaire Survey, June-October, 2016

4.4.8 Income

Income level is important to assess financial strength and livelihood security in any adverse situation. The present study finds that 38.7%, 47.9% and 13.4% of the sampled respondents fall in the income group of BDT <45000, 45000-90000 and > 90000. Less income per year is higher in Gabura, Lalua and Bharuakhali as 50.0%, 35.1% and 63.0% respectively. Middle income group is higher in Nilgonj, Gabura and Munshigonj as 67.3%, 64.9% and 44.4% respectively. In higher income group Khurushkul, Munshigonj and Gabura hold the major portion as 32.1%, 18.1% and 12.5% respectively. This finding reveals that Munshigonj, Nilgonj and Khurushkul are comparatively stay in better position regarding income per year.

Table 4.10: Income Level of Households by Study Unions

Annual Income Level (In Taka)		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
<45000	n	27	36	20	14	21	29	147
	%	37.5%	50.0%	35.1%	28.6%	25.0%	63.0%	38.7%
45000-90000	n	32	27	37	33	36	17	182
	%	44.4%	37.5%	64.9%	67.3%	42.9%	37.0%	47.9%
>90000	n	13	9	0	2	27	0	51
	%	18.1%	12.5%	0.0%	4.1%	32.1%	0.0%	13.4%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Source: Questionnaire Survey, June-October, 2016

4.5 Major Livelihood Groups

Socio-economic class variation in coastal Bangladesh is defined by different measures. People's occupations and associations of production often portray livelihood groups, for example fishers, day labor or wage labor are classified as distinct social class with low status. The large land owners are elite rural people who are also important part in socio economic classes in coastal zone.[9] Agricultural labor is the largest livelihood group in terms of number in coastal zone. Generally, one in every three households is depended on agriculture. Small farmers are the transitional groups between landless and large landowners though they are very close to landless. Fishermen are the single largest groups among the nonagricultural occupations. However, livelihoods in the coastal Bangladesh are broadly clustered into two groups such as natural resource based like agriculture, fishing, aquaculture, extraction of forest resources etc. and human resource based like boat building, net making, fish processing, trading etc. There are about seven million households in coastal zone, out of which agricultural laborer, small farmer, fisher and urban poor cover 71% of total households.[10]

As the all the study unions are situated in exposed coastal zone most of the respondents are involved in fishing occupational group. It is found in the field study that many of the respondents are involved in fishing simultaneously agriculture. Number of fishing and

[9] M. H. Minar, M. Belal Hossain and M. D. Shamsuddin, "Climate Change and Coastal Zone of Bangladesh: Vulnerability, Resilience and Adaptability," *Middle-East Journal of Scientific Research* 13, no. 1 (2013): 115.

[10] Bangladesh Bureau of Statistics, *Statistical Yearbook of Bangladesh 2011*. 31st ed. Bangladesh Bureau of Statistics, Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh (Dhaka: September 2012).

farming are about to same. A big portion of the study area is involved in different wage labor sectors. Here different groups are calculated in wage labor sector. In farming sector Lalua holds the highest portion (49.1%) followed by Munshigonj, Gabura, Nilgonj and Bharuakhali. Gabura is very much adjacent to sea and highest portion is involved in fishing (44.4%). In wage labor section Bharuakhali and Khurushkul hold the highest portion. As the scope of farming and fishing is comparatively lesser here, most people involve themselves in wage labor sector like salt industry for livelihood option.

Table 4.11: Major Livelihood Group-wise Household Distribution

Occupation wise household distribution		Study Villages						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Farmer	n	26	18	28	7	12	1	92
	%	36.1%	25.0%	49.1%	14.3%	14.3%	2.2%	24.2%
Fisher	n	27	32	10	3	20	10	102
	%	37.5%	44.4%	17.5%	6.1%	23.8%	21.7%	26.8%
Wage labor and others	n	19	22	19	39	52	35	186
	%	26.4%	30.6%	33.3%	79.6%	61.9%	76.1%	48.9%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Source: Questionnaire Survey, June-October, 2016

4.6 Housing Pattern

Housing pattern is measured by some indicators, such as type of materials used for roof, wall and floor. However, especially roofing material of house alone also reflects standard of housing in rural Bangladesh context. Selection of these housing materials depends on the cultural and socio-economic condition of households such as income, family size, and cultural practices etc. Accordingly, selection of permanent roofing material for example corrugated iron (CI) sheets represents relatively better standard of housing than the houses use straw/grass as roofing materials. Similarly, all six study unions have little facilities of the service of electricity. Therefore, households having solar panel for electricity reflects relatively better standard of housing.

The present study finds that majority of the respondents had used CI sheets as roofing materials for housing. On the other hand, straw and polythene were more preferred roofing materials over CI sheets. Similarly, use of wall materials for housing significantly varies among the villages. Few respondents had used wood and bamboo as wall materials;

however most of them were in Inland village. In rural Bangladesh context floor of the house are prepared by mud on elevated earthen ground. In few cases roof and walls are constructed by CI sheets and floor is prepared by bricks and cements. Such type of houses reflects better standard of housing in rural Bangladesh context. Few of such houses were found in study unions (Appendix table 3).

4.7 Chapter Summary

This chapter analyzes geophysical settings of the study area, socio-economic profile of the respondents. All six study unions are located in the different coastal regions (i.e. eastern, central and western coastal zone) of Bangladesh, which experience tropical monsoon climate. Apart from the majority of Bengali population some tribal groups are living in this area.

The present study finds that out of the total households about 85% are male and 15% are female headed. The average age of household head is 44 years and their average duration of stay in same village is about 40 years. This study also finds gender dimension of climate change impacts, which unveils that out of total victims children and female are higher in number. Therefore, this confirms the well accepted proposition of women and children are the worst victims of any future adversity. Some of the respondents in coast-line unions were settled from different interior locations; meaning respondents spatial mobility in terms of permanent settling to disaster prone vulnerable locations are very common in coastal Bangladesh.

More than 60% of the respondents are illiterate followed by educational level of grade five is 23% and grade ten and above is 5% . Major primary occupations of respondents are wage labor and others (48.9%) followed by fisher (26.8%) and farmer (24.2%). Other common supplementary occupations are petty business, formal service and various agriculture and off-farm activities. Dependency on agriculture is higher in Lalua.

Average ownership of agricultural land is 0.33 acres. However, 48.7% of the respondents do not have any agricultural land. This reveals agricultural land holding is highly uneven distributed as the majority of the large land owners remain absent in the locality.

From FGD during the time of field survey it was found that among the six study locations Gabura, Lalua and Bharuakhali union had experienced significantly higher property loss and loss of lives than Munshigonj, Nilgonj and Khurushkul union due to hydro-meteorological events. Several earlier studies find that study villages are historically vulnerable to different climatic events.[11] However, in recent times human life loss is significantly reduced due to the locational exposure, protection through embankment, mangrove forest, availability of cyclone shelter etc. but associated loss of properties has increased significantly.

[11] C.E. Haque, and D. Blair, "Tropical Cyclones: Evidence from the April 1991 Cyclone in Coastal Bangladesh," *Disasters* 16, no.3 (1992): 217.

Chapter Five
Potential Impact of Sea Level Rise on Livelihood in Coastal Bangladesh

5.1 Introduction

Climate Change is already an unpleasant reality in Bangladesh. The potential total sea level rise over the period of the end of the 21st century relative to the end of the 20th century is estimated to be an increase in the sea level between 18 and 59 cm. The main consequence of the rising of sea level is that the deltas and island will undergo coastal inundations.[1] The reason for this is because deltas and small island states are vulnerable to sea level rise because of their size and height above sea level. The flooding of coasts that are highly populated will cause a major impact in the economic and social problems of the future. Bangladesh is the most vulnerable to sea-level rise. The country is very low-lying and sits on the northern part of the sea that is close to the Bay of Bengal. In addition to being one of the world's poorest nations, this country has also experienced many catastrophic events in the past such as severe storm surges, coastal flooding with saline water inundation, disastrous coastal cyclone etc.

SLR has the potential to interact with the coastal zone in a number of ways including inundation, erosion and salt water intrusion. Inundation and intrusion will clearly be affected by the relatively slow increases in sea level over the next century and beyond. The characteristics of extreme sea level rise events are dependent on the atmospheric temperature intensity and movement of coastal geometry.

5.2 Sea level Rise Consequences in Bangladesh

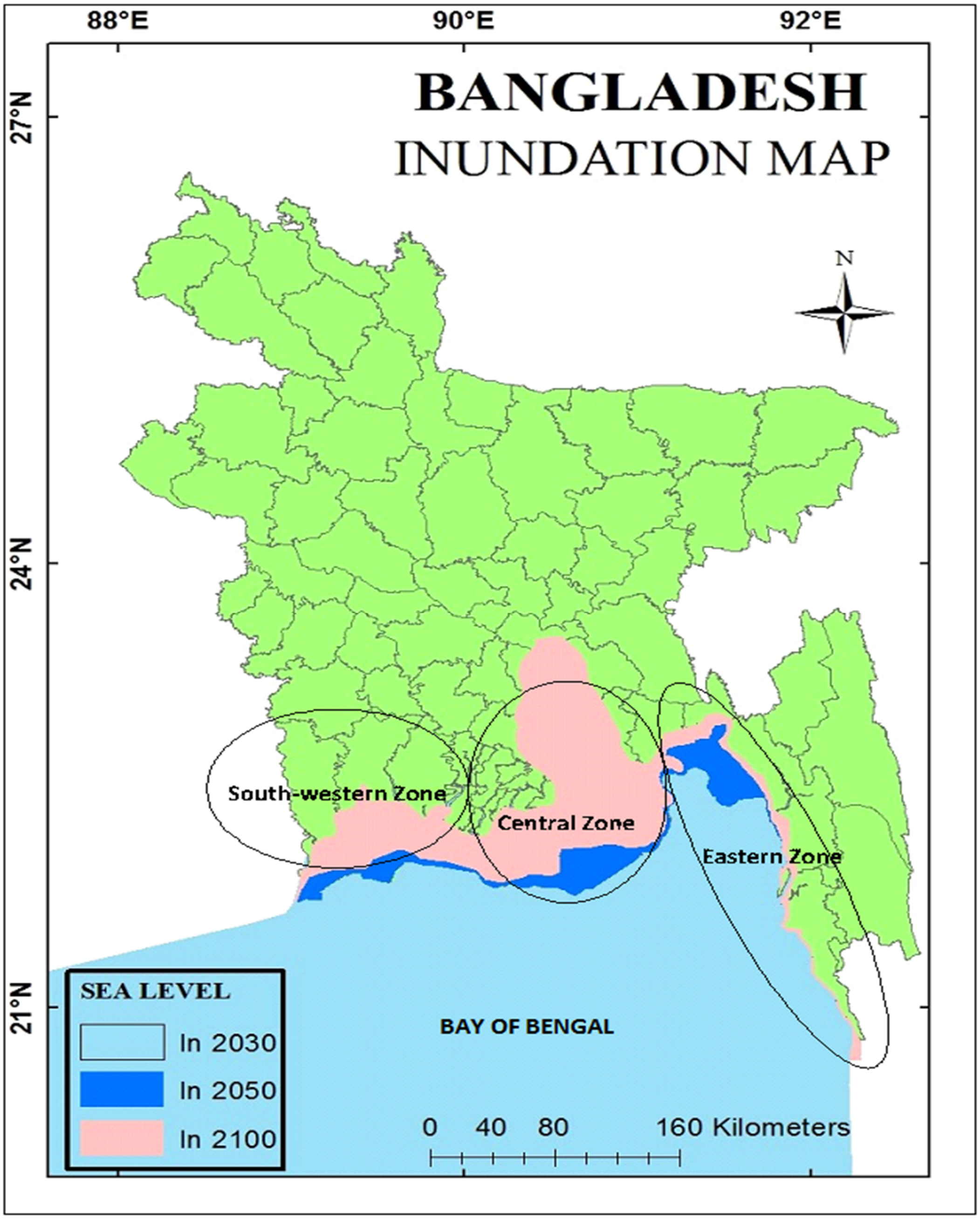
Bangladesh is one of the poorest and most densely populated countries in the world. With more than 152 million people in such a small area over population is a major problem, and recent estimates suggest that population growth will continue despite the Government's efforts to control it. Eighty percent of the nation's area of 144,000 square kilometers is made up of the complex Bengali delta system created by the Ganges, Brahmaputra and Meghna Rivers. One of the most striking geomorphological features of this nation is its coastal topography, characterized by vast stretches of flood plains barely

---

[1] IPCC, Climate Change 2007: *Synthesis Report*. Intergovernmental Panel on Climate Change. Available at: http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf (Accessed 22 March 2016)

above sea level. Only a few places in the entire country rise more than 20 m above sea level. Global warming may raise

Figure 5.1: Projected Inundation Map of Bangladesh Due to Sea Level Rise



Source: *Author*

(*ArcGIS10*.2.2 Model Map of Different Inundation Status of Bangladesh Due to Sea Level Rise in 2030, 2050, 2100.)

the sea level up to 2 m worldwide over the next 100 years (Figure 5.1). A rough estimate of the spatial distribution of the population in this country indicates that more than 20% of the total populations live in the area that will be submerged. Other major problems are the exposures of the population to storm surge and strong winds in the coastal zone of Bangladesh. Scientists believe that as warming continues, it will not only cause of sea level rise, but will also intensify the pattern of cyclonic storms. Particularly affected areas will be around the area of coastal zone, inhabited by large number of coastal people.

Sea level rise will have an economic impact on the agricultural sector which accounts for 55% of the nation's gross domestic product and provides a livelihood for over 85% of the population. Agriculture is the source of raw material for much of the small industrial sector. More than 25% of the agricultural output comes from low-lying areas that are susceptible to floods. A sea level rise will cause salt water to enter fresh groundwater reservoirs. Salt water intrusions even now extend as far as 290 km inland.[2] In southern Bangladesh, the Sundarbans region, regularly inundated by the sea during high tides, is one of the world's largest mangrove forests.[3] With 8,000 km of waterways Bangladesh is one of earth's largest delta systems. The fresh water delta fisheries are the country's most important source of animal protein. Fishing these waters provides a livelihood for about 1.5 million people and generates 4% of the Gross Domestic Product.[4] This important food source would be diminished by salt water intrusion in the event of a gradual sea level rise of one meter or more. The other consequences for the biotic environment, especially in the coastal areas where vast stretches of mud flats, swamps and newly emerging islands are all specialized habitats of great ecological significance.

Coastal regions of Bangladesh is at great risk from projected sea-level rising. Coastal zone resources are especially endangered by the projected climate change and consequent sea level rising. Potential impacts would include: (i) changes in water levels and induced inundations and water logging, (ii) increased salinity in ground and surface water, and corresponding impacts on soil salinity, (iii) increased coastal morphological dynamics

[2] World Bank, "Bangladesh: Climate Change & Sustainable Development. Dhaka, World Bank Office." *South Asia Rural Development Team* (2000), Available at http://documents. worldbank.org/ curated/en/906951468743377163/Bangladesh-Climate-change-and-sustainable-development (Accessed on 15 March 2016).

[3] Golam Sarwar, *Impacts of Sea Level Rise on the Coastal Zone of Bangladesh*, available at www.pg-du.com/wp-content/uploads/2012/02/golam_sarwar.pdf development (Accessed on 17 March 2016).

[4] J. M. Broactus, "Possible Impacts of, and Adjustments to, Sea Level Rise: The Cases of Bangladesh and Egypt," *Climate and Sea Level Change: Observations, Projections, and Implications* 5 (1993): 263.

(erosion and accretion), and increased incidence of natural hazards. These impacts will lead to the reduction of the economic and employment opportunities in the coastal areas.

5.3 Potential Impact on Livelihood Security of Sea Level Rise in Bangladesh

Coastal ecosystems and communities in Bangladesh are commonly known to be vulnerable to rising sea levels and other climate-change impacts, as documented in the various assessment reports of the Intergovernmental Panel on Climate Change (IPCC). Impact on livelihood of sea level rise on the coastal region of Bangladesh for 100 years into the future is challenging. There are many confounding variables on the livelihood security side as well as environmental. The potential losses of coastal habitat are to be expected by the consequences of Sea level rise as salinity intrusion, fisheries and aquaculture, agriculture, landmass, settlement, health, security etc.

To address the research questions about the impact of sea level rise on livelihood security of coastal region of Bangladesh stated in the introduction part, a semi-structured questionnaire was prepared and tested in the study area before conducting the actual field survey. The questionnaire included among others various socio-economic and demographic information of the family, their exposure to various disasters, the damage that they experience due to recurrent disasters, their perception about the changing nature of climate, extreme events and sea level rise, and the likely impacts of these events on their live and livelihood**.**

As the study area is traditionally exposed to multiple-hazards, the respondents are in general familiar with the impacts of cyclone, tidal surge, coastal inundation, salinity intrusion. They have a common perception that extreme events are more pronounced in recent time than these had been earlier. Respondents were asked to identify the likely impacts of various hydro-meteorological events including SLR especially if their farmlands gradually go under half of knee-deep water (20–25 cm) forever. Similarly, they were asked about the impacts of the associated impacts they will encounter if height of the level of the sea rises. The use of this kind of reasonable scenarios of climate change for studying the perception of common people is a widely accepted method.[5] To facilitate their responses, a total of 27 plausible impacts were included in the questionnaire.

[5] James D. Ford and Barry Smit, "A Framework for Assessing the Vulnerability of Communities in the Canadian Arctic to Risks Associated with Climate Change," *Arctic,* no 4, 57(2004): 392.

This list of 27 impacts of climate change induced hydro-meteorological events was prepared from the review of literature of climate and disaster. The coastal people have rated each of these impacts on their natural resource based livelihood in a simplified 5-point Likert scale. A 5-point Likert scale is widely used, to facilitate the responses of rural illiterate/less educated respondents. For detail analysis it is finally transformed in to three point scale. As high and very together make high, no change for medium and low and very low together make low scale. As the study area is completely climatic perilous zone so, the inhabitants have high level perception about different impacts about exposures.

The study reports (table 5.1) that more than 60% respondent's livelihood security might be highly impacted by damage of human settlement, threat of food security and dropping of total household income.

More than 50% respondents acknowledged that due to sea level rise their livelihood security would be impacted by salinity intrusion, damage of nonfarm economy, loss of production of crop and livestock, water born diseases, sea level rise refugee. Similarly more than 40% respondents think high livelihood insecurity due to sea level rise which increases higher storm surge, inward migration of mangrove forest, damage of nonfarm economy, damage of social institution and increase of health hazard. Severe threat to these dimensions of livelihood security is acknowledged by a large number of population because these are the common dimensions of livelihood security of most occupational groups in the study area.

Livelihood insecurities of many other families are highly related to damage of fish ponds/enclosures, higher risk in offshore fishing, decrease in fish catch per go. Some other impacts, for instances, damage of road infrastructure, difficulty in physical mobility, difficulty in carrying commodity and goods, spread of contaminated water, and prevalence of waterborne diseases also will cause the livelihood of coastal people insecure in the changing context of climate.

Opposing to general expectation, more than 30% respondents acknowledged that their livelihood security is rather medium impacts in the dimensions of damage of fish ponds/farms, higher risk in offshore fishing, increase number of non-fishing day, decrease in fish catch per go, difficulty in preserving fish, salinity inundation, nonfarm economic activities and water born diseases.

More than 20% of the respondents assigned a low score for each of these dimensions of livelihood insecurity. It is probably because the livelihood challenges in these dimensions are related to only a particular occupational group. It is observed that one community has higher concern for certain livelihood security while other livelihood group is different from that. For example, fisher-group expressed higher concern in certain dimensions of livelihood security, however, agricultural group expressed different dimension. About 10–20 % of the respondents mentioned that they will experience low level of impacts in their livelihood security in the dimension of inundation, damage of settlement, loss of agricultural land, water born diseases, food security, fish preserving, scarcity of source of drinking water and total house hold income (table 5.1).

Table 5.1: Types of Possible Livelihood Insecurity due to Sea Level Rise in the Coastal Zone of Bangladesh

Indicators of Livelihood Insecurity	High		Medium		Low	
	%	f	%	f	%	f
1. New areas under water	***52.89***	***201***	***25.53***	***97***	***21.58***	***82***
2. Permanent inundation of covering large area	***51.32***	***195***	***26.32***	***100***	***22.37***	***85***
3. Temporary inundation of covering large area	49.74	189	39.47	150	10.53	40
4. Increase in basin for higher storm surge	42.63	162	47.37	180	9.74	37
5. Increase soil salinity	***57.89***	***220***	***26.58***	***101***	***15.53***	***59***
6. Increase surface water salinity	***53.95***	***205***	***31.58***	***120***	***14.47***	***55***
7. Inward migration of Mangrove forest	49.21	187	39.47	150	11.32	43
8. Loss of agricultural land	***52.63***	***200***	***27.11***	***103***	***20.26***	***77***
9. Loss of pasture	***53.95***	***205***	***28.68***	***109***	***17.37***	***66***
10. Damage of nonfarm economic activity	49.74	189	32.63	124	17.63	67
11. Damage of human settlements	***63.16***	***240***	***27.89***	***106***	***8.95***	***34***
12. Damage of Economic infrastructure	***53.42***	***203***	***28.68***	***109***	***17.89***	***68***
13. Damage of Social Institutions	45.26	172	31.58	120	23.42	89
14. Scarcity in source of potable water	***55.26***	***210***	***28.42***	***108***	***16.32***	***62***
15. Loss of production in crop agriculture & horticulture	***56.84***	***216***	***29.21***	***111***	***15.53***	***59***
16. Loss of production in livestock	***51.84***	***197***	***29.74***	***113***	***18.42***	***70***
17. Loss of complementary/supplementary income	***52.63***	***200***	***28.16***	***107***	***19.21***	***73***
18. Restricted physical mobility of people, goods & services	50.26	191	23.68	90	26.32	100
19. Limited social interaction and mobility of people	***51.05***	***194***	***22.37***	***85***	***26.58***	***101***
20. Prevalence of Waterborne disease	***57.37***	***218***	***31.32***	***119***	***11.32***	***43***
21. Threatened food security	***61.84***	***235***	***26.32***	***100***	***11.84***	***45***
22. Drop in household total income	***60.26***	***229***	***26.05***	***99***	***13.95***	***53***
23. Increase in household expenditure	***55.26***	***210***	***27.11***	***103***	***17.89***	***68***
24. Environmental degradation, health hazard & increased cost for medication	48.16	183	29.21	111	22.63	86
25. Difficulty in preserving fish	***54.21***	***206***	***31.58***	***120***	***14.21***	***54***
26. High pressure on limited safer area nearby to accommodate migrants likely to be forced to evacuate	50.26	191	32.89	125	16.84	64
27. Sea Level Rise Refugee	***57.37***	***218***	***27.11***	***103***	***15.53***	***59***

Source: Questionnaire Survey, June-October, 2016

5.4 Livelihood Affecting Impact of CC-SLR: A Comparative Analysis in the Study Area

Impact of sea level rise is highly diverse among all other geo-hydrological adversities induced by climate change in terms of the coastal zone of Bangladesh. To find out the area to be affected severely, an attempt was taken from the perception of the respondents. Only a well aware community can effectively appraise the level of future threat.[6] Earlier studies, for example, basically use 'familiarity with climate change/weather extreme phenomena' as indicator of awareness about climate change. Likewise, some earlier literature use 'perception/belief' as indicator of climate change related events.[7] While others, for example, use 'intuitive knowledge' as indicator of awareness in the context of climate change and related environmental phenomena.[8] For this study all these aspects are taken into account for framing indicators to relate with CC-SLR.

There are various environmental, economic, non-economic, social, tangible, and intangible kind impacts of SLR. For better analysis it has been categorized the impact into three parts. These are Biotic impact, Abiotic impact, and Socio-economic impact. All these consequences are inter-related and affect livelihood enormously.

5.4.1 Biotic Impact

In biotic impact human activities are mainly considered. Climate change induced sea level rise has serious impact on biotic environment. The human activities those who are affected by sea level rise are fall into biotic stress. The Impact directly affect the human activities are discussed here. These are

5.4.1.1 Impacts on Agriculture

The study area presently experiences severe flooding due to storm surge activities and tidal waves, which can be attributed to a relative sea-level rise as a result of climate change. A significant percentage of the population will lose property due to increased flood erosion. Increased erosion in recent times continues to threaten agricultural activities. During household survey in field study respondents were interviewed about

---

[6] Torsten Grothmann and Anthony Patt, "Adaptive Capacity and Human Cognition: The Process of Individual Adaptation to Climate Change," *Global Environmental Change* 15, no. 3 (2005): 203.

[7] Ibid., 205.

[8] B. Steel, N. Lovrich, D. Lach and V. Fomenko, "Correlates and Consequences of Public Knowledge Concerning Ocean Fisheries Management," *Coastal Management* 33(2005): 38.

loss of production decreasing due to SLR. About 7.1% of total respondents agreed decreasing of crop agriculture as medium possibility followed by 89.0% as higher possibilities and the rest 3.7% think no possibility. Lalua union is assessed as most vulnerable as per respondents' perception (table 5.4). There is also significant difference found among the areas. Lalua union holds the higher level of impact on agriculture. The finding is similar to previous study as presented in table 5.2.[9]

Table 5.2: Effect of 1 m Sea Level Rise on Agriculture (major crops)

Crop	Area affected (Ha)	Total for Bangladesh (%)
Aman (Monsoon) rice	1,280,000	21
Aus (Summer) rice	40,000	12
Boro (Winter) rice	102,000	8
Jute	13,800	2

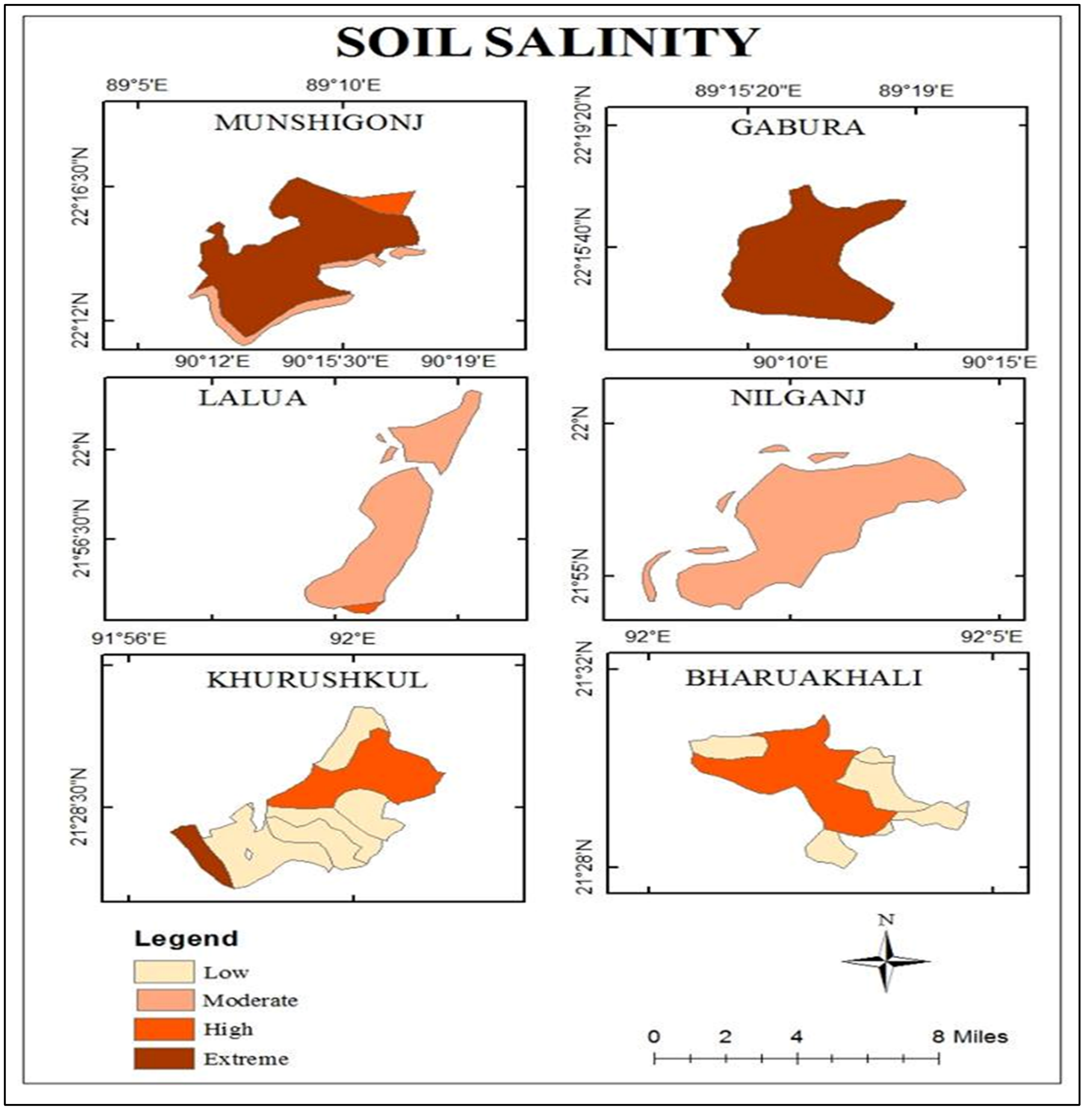
Source: Saleemul Huq, Ali Syed Iqbal, and A. Atiq Rahma, "Sea-Level Rise and Bangladesh: A Preliminary Analysis." *Journal of Coastal Research,* SI 14(1995): 45.

The result is also consistent with the study that salinity intrusion due to sea level rise will decrease agricultural production by unavailability of fresh water and soil fertility. Salinity also decreases the terminative energy and germination rate of some plants.[10] The salinity is gradually increasing which is reflected by the figure (figure 5.2). Projected different SLR scenarios will acutely exaggerate the situation.

[9] Saleemul Huq, Ali Syed Iqbal, and A. Atiq Rahman, "Sea-Level Rise and Bangladesh: A Preliminary Analysis," *Journal of Coastal Research,* SI 14(1995): 45.

[10] M. M. Rashid, A. K. F. Hoque and M. S. Iftekhar, "Salt Tolerances of Some Multipurpose Tree Species as Determined By Seed Germination," *Journal of Biological Sciences* 4, no. 3 (2004): 288.

Figure 5.2: Present Soil Salinity Position of the Study Unions



Source: Bangladesh Agricultural Research Council, 2016 (*ArcGIS10*.2.2 Model Map on Salinity).

Table 5.3: Present Soil Salinity Range in Study Area

Union	Soil Salinity Range (% Area)				
	Extreme (>16) µS/cm	High (8-16) µS/cm	Moderate (4-8) µS/cm	Low (<4) µS/cm	Total
Munshigonj	84.7	6.2	9.1	0.0	100.0
Gabura	100.0	0.0	0.0	0.0	100.0
Lalua	0.0	6.3	93.7	0.0	100.0
Nilganj	0.0	0.0	100.0	0.0	100.0
Khurushkul	7.8	26.9	65.3	0.0	100.0
Bharuakhali	0.0	61.2	38.8	0.0	100.0

Source: Bangladesh Agricultural Research Council, 2016.

It is clear that Gabura is the most vulnerable (extreme level) place regarding soil salinity followed by Munshigonj and Khurushkul union. SLR will make the scenario more critical. Due to excessive salinity a significant portion of people will turn into shrimp farming. It is found from FGD during field survey that is practicing shrimp cultivation in saline water has a serious drawback as it decreases rice production due to degraded soil quality. It is found that the decrease rate is very high and the scene is common for almost all rice fields in coastal districts.

The scenario is parallel to the findings about increasing of salinity alone from a 0.3 meter sea level rise will cause a net reduction of 0.5 million metric tons of rice production. Sea level rise affects coastal agriculture, especially rice production in two ways. Salinity intrusion degrades soil quality that decrease or impede rice production. When the rice fields are converted into shrimp ponds, total rice production decreases because of decreased rice field areas. Farmers couldn't produce two rice crops in one calendar year, as one vegetation cycle is used for shrimp cultivation instead. For that reason, the decrease in production is seemingly too high compared to the decrease in area.[11]

If we try to find out the picture of sea level rise impacts on agriculture of Bangladesh, it shows almost similar behavior as in the case of other coastal agricultural production. Sea level rise affects agriculture in three ways, i.e. by salinity intrusion, by flooding and by increasing cyclone frequency and its depth of damage. Combined effects of these three factors decrease agriculture production in the coastal zone. Decreased agriculture will cause decrease GDP. If agricultural production is decreased, food and cash crop production will be decreased too. Decreased food production will cause food shortage leading to health hazards or even famine. The ultimate result of the reduction of agricultural production will create poverty that will force Bangladesh to seek aid from other countries.

[11] M. M. Rashid, A. K. F. Hoque and M. S. Iftekhar, "Salt Tolerances of Some Multipurpose Tree Species as Determined By Seed Germination," *Journal of Biological Sciences* 4, no. 3 (2004): 289.

Table 5.4: Loss of Production in Crop Agriculture

Loss of Production in Crop Agriculture		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
No Possibility	n	5	2	0	4	1	2	14
	%	6.9%	2.8%	0.0%	8.2%	1.2%	4.3%	3.7%
Medium Possibility	n	7	4	2	8	2	4	27
	%	9.8%	5.6%	3.6%	16.4%	2.4%	8.6%	7.1%
High Possibility	n	60	66	55	37	81	40	339
	%	83.3%	91.7%	96.5%	75.5%	96.4%	87.0%	89.0%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Likelihood Ratio	Value= 39.136, df = 20, p=.001							

Source: Questionnaire Survey, June-October, 2016

5.4.1.2 Impacts on Health

Livelihood security is closely linked with health security. To find out the potential impact of health due to SLR respondents were interviewed about the issue in different ways like prevalence of waterborne diseases and finally 41.0% of the respondents opined about moderate possibility, 49.2% of the respondents answered as high possibilities of health impact. A portion of respondents about 9.7% could not decide whether the impacts would happen or not due to ignorance about the health adversity (table 5.6).

The findings of the study admit the previous study that sea level rise related health hazards are to be considered for future livelihood security**.** It may increase the risk of health hazards such as diarrhoea, cholera, etc. Cholera is an infectious disease of the small intestine of human beings and is common in the coastal area of Bangladesh. *Vibrio cholera* is the causing microorganism of cholera that survive longer with salinity level ranging from 2.5 ppt to 30 ppt and need Sodium ion (Na) for growth.[12] Average salinity of sea water is 35 ppt or 3.5%. Most of the salt present in the seawater is sodium chloride (NaCl) that breaks up into Na and Cl ion when dissolved in water. For the reason, coastal area is breeding and nursery ground of cholera disease.

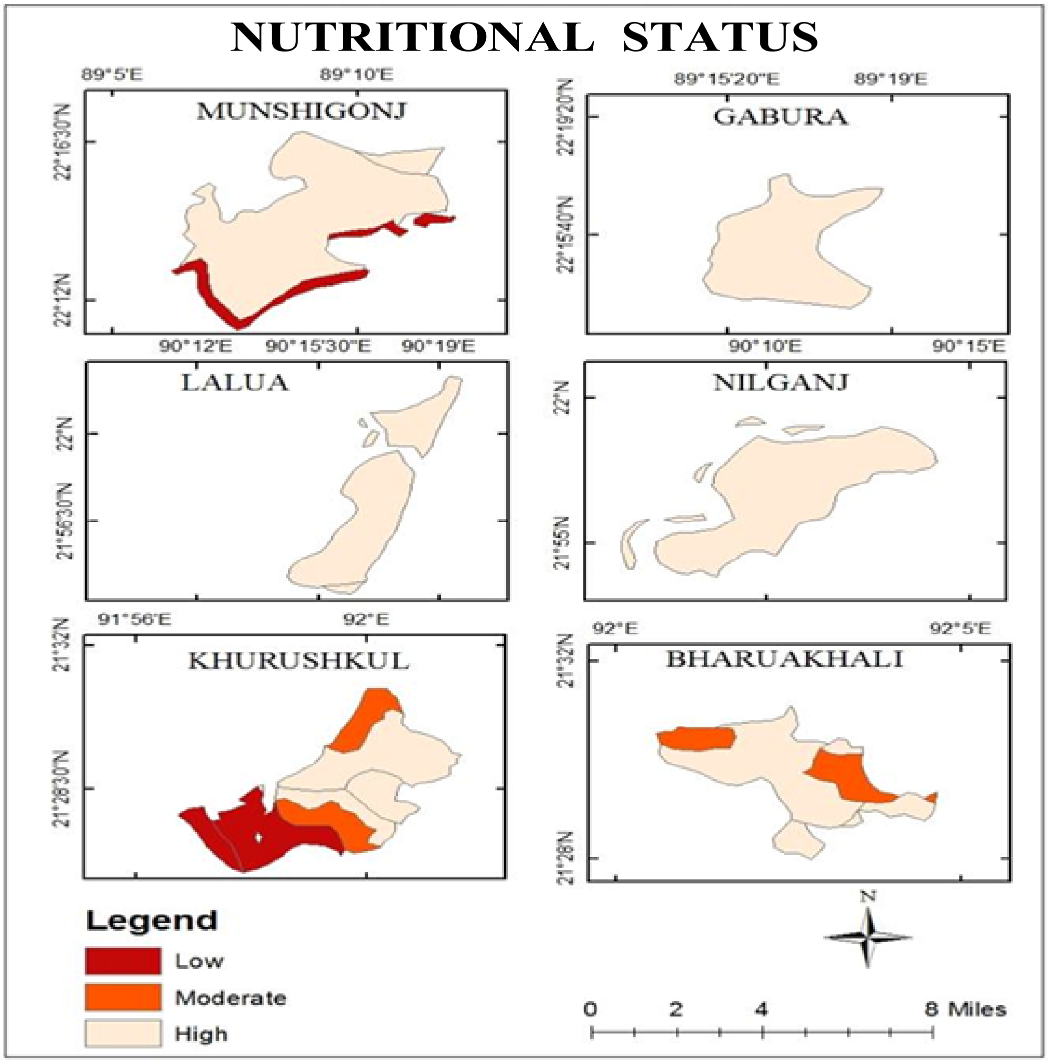
[12] R J. Borroto, "Global Warming, Rising Sea Level, and Growing Risk of Cholera Incidence: A Review of the Literature and Evidence," *GeoJournal 44*, no.2 (1998):111.

Another study also supports this that water salinity of the coastal area of Bangladesh varies from 0 ppt to 20 ppt.[13] Water salinity and its distribution in the coastal area are increasing with the increase of sea level rise. With the increased density and distribution of salinity, cholera germs are getting favorable habitat and spreading in the coastal area. This hypothesis is also supported by the statement that the most major epidemics of Cholera which have occurred during the last 50 years originated in coastal region.[14] So, coastal water and its saline environment have close association with cholera disease. Outbreaks of cholera often occur after flooding, because the water supply becomes contaminated. Thus, sea level rise, by increasing flood risk, increase the risk of cholera outbreak too.

Increased stress on the fresh water zone by saline sea water will decrease fresh water availability in the coastal zone. Increased unavailability of fresh water will force people to drink contaminated water leading to cholera, diarrhoea and other water born diseases. Again, increased salinity in the coastal zone will decrease food production in the area, causing malnutrition for the coastal people. Present nutrient position of the study area is presented in figure 5.3. Gabura, Lalua and Nilgonj Unions are found vulnerable area regarding nutrient position. Projected sea level rise with saline water inundation will make the situation more critical in terms of coastal people nutrition status.

[13] Salinity is measured in parts per thousand (ppt), grams of salt per 1,000 grams of water.
[14] Ben J. Smith, Kwok Cho Tang, and Don Nutbeam, "WHO Health Promotion Glossary: New Terms," *Health Promotion International* 21, no. 4 (2006): 340.

Figure 5.3: Present Nutrient Status of Respondents in the Study Unions



Source: Bangladesh Agricultural Research Council, 2016 (*ArcGIS10*.2.2 Model Map on Nutrient Status).

Table 5.5: Present Nutritional Status in Study Area

Union	Nutrient Status (% Population)			
	High (<1600 K.Cal)	Moderate (1805 K.Cal)	Low (2122 K.Cal)	Total
Munshigonj	83.2	16.7	0.0	100.0
Gabura	95.0	5.0	0.0	100.0
Lalua	87.0	13.0	0.0	100.0
Nilganj	80.0	10.0	10.0	100.0
Khurushkul	33.7	39.8	26.5	100.0
Bharuakhali	0.0	22.1	77.9	100.0

Source: Bangladesh Agricultural Research Council, 2016.

So, it can be concluded that sea level rise will accelerate waterborne diseases and malnutrition in the coastal area concurrently. However, the degree of probability of cholera and the depth of malnutrition is a matter of further exploration. Waterborne diseases are life threatening to the coastal people. Future events of SLR is highly alarming for human health of coastal area.

Table 5.6: Prevalence of Waterborne Diseases due to Sea Level Rise

Prevalence of Waterborne Diseases		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
No Possibility	n	4	7	6	5	10	5	37
	%	5.6%	9.7%	10.5%	10.2%	11.9%	10.9%	9.7%
Medium Possibility	n	29	37	28	23	30	9	156
	%	40.3%	51.4%	49.1%	46.9%	35.7%	19.6%	41.0%
High Possibility	n	39	28	23	21	44	32	187
	%	54.2%	38.9%	40.5%	42.8%	52.4%	69.6%	49.2%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Likelihood Ratio	Value= 47.641, df = 20, p= .000							

Source: Questionnaire Survey, June-October, 2016

5.4.1.3 Impacts on Tourism

The major part of Bangladesh's coast is world's prominent sandy beaches, so it attracts the tourists round the world. Kuakata beach in Patuakhali district, Patenga beach in Chittagong district and Cox's Bazar beach in Cox's Bazar district are attractive tourist areas of the country. Cox's Bazar sea beach is the world's largest attractive sandy beach having a length of 145 km.

All the tourist facilities in the coastal zone will be affected by sea level rise directly or indirectly. Tourism sector of Kuakata will suffer the most because all the facilities are very close to the coastline and the area is more vulnerable comparative to Cox's Bazar and Chittagong. However, all the mentioned areas are highly vulnerable in terms of sea level rise related natural disaster, e.g. flood, storm surge, etc. In this regard, respondent were interviewed about impact on tourism of SLR. In this context, 11.9% of the respondents agreed about the medium possibility of impact of SLR on tourism and 83.4% of the respondents commented on high possibility and rest 4.7% of the respondents think no possibility. From these findings it is clear that most attractive Cox's Bazar is the most vulnerable area regarding impact of tourism from the perception of the respondents as the tourism play vital role for livelihood security of the people of Cox's Bazar. The finding supports the previous study regarding impact of SLR on tourism.[15]

Every year a good number tourists visit the zone of home and abroad. By the selection of Parjatan Corporation of Bangladesh Chittagong, Cox's Bazar, Kuakata, Khulna and the Sundarbans are the five tourist spots among eighteen tourist area in the coastal zone of Bangladesh. Some tourism related infrastructures are situated in the coastal zone. A study of Bangladesh Parjatan Corporation suggests that 19% of foreigners visiting Bangladesh are tourists, the rest visit Bangladesh for business or other official purposes. At national level, tourism industry serves the nation with economic development. At the local level, it helps to strengthen local economy, culture and heritage. Sea level rise, by affecting this promising sector will affect the national economy and heritage of Bangladesh.

Table 5.7: Decrease to Tourism Opportunities

Decrease of Tourism Opportunities		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
No Possibility	n	4	5	3	1	3	2	18
	%	5.6%	6.9%	5.3%	2.0%	3.6%	4.3%	4.7%
Medium Possibility	n	14	13	6	1	7	4	45
	%	19.4%	18.0%	10.6%	2.0%	8.4%	8.6%	11.9%
High Possibility	n	54	54	48	47	74	40	317
	%	75.0%	75.0%	84.2%	95.9%	88.1%	87.0%	83.4%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Likelihood Ratio	Value= 46.900 df = 20 p= .001							

Source: Questionnaire Survey, June-October, 2016

5.4.1.4 Impacts on Fisheries and Aquaculture

Sea level rise would have serious impact on river structure. It would change the location of the river estuary, causing a great change in fish habitat and breeding ground. It is considered that Sea level rise is helping shrimp farming by introducing salinity in the coastal area, but it is also harmful. If we consider another sea level rise phenomena, for instance flooding; it is doing massive harm to the sector by overflowing shrimp pond and it creates inconvenient situation for shrimp cultivation. Respondents were asked to

[15] Md Shahadat Hossain, "Biological Aspects of the Coastal and Marine Environment of Bangladesh," *Ocean & Coastal Management* 44, no. 3 (2001): 264.

provide their perception about the impact of SLR on Fisheries and Aquaculture. Their responses support mainly medium level of impact on production of fisheries as 49.2% of the respondents. They commented that shrimp farm will be supported by the saline water. In Lalua, Khurushkul and Munshigonj are in vulnerable position with high problematic situation as 35.1%, 29.8% and 22.2% respectively of the respondent's perception (table 5.8).

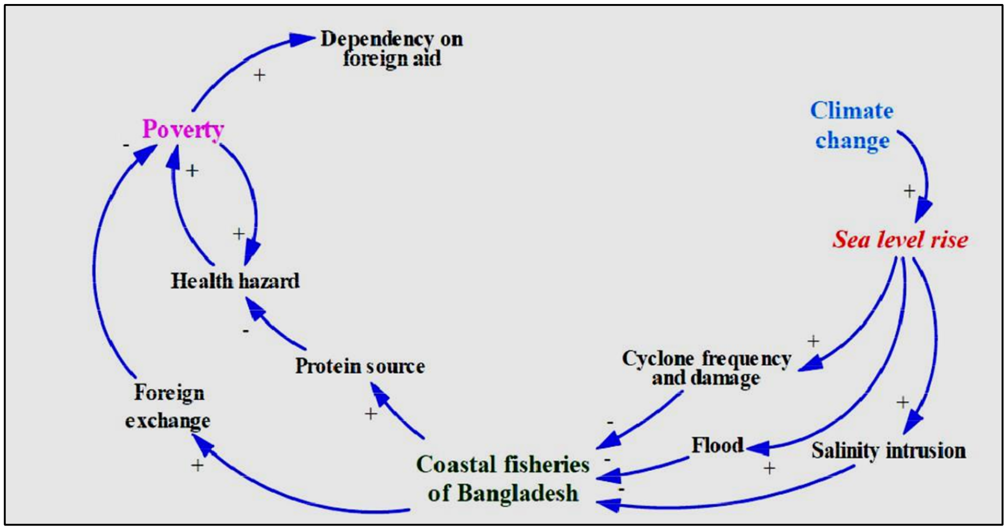
In coastal area of Bangladesh there are some fisheries service centers for providing support in fishing industry. These centers facilitate the fishery sector with fuel supplies, landing, whole sale, icing, inland transportation and other activities with an aim to improve the yield of the sector. These service centers are much closer to coastline or estuaries. Sea level rise would be harmful as the area potential to be inundated by saline water. There are some areas in the coastal zone that are far from city or fisheries service centre and have no icing facilities. By the indigenous knowledge Fishermen of such areas dry fishes in open sunlight to avoid spoilage. Locally these dry fishes are known as 'Shutki'. Dry fishes are rich in nutrient value and a popular among the coastal people, especially in the southeastern coastal zone. The dry fish industry will be affected by anticipated sea level rise.

If we search the cause-effect relationships of sea level rise and coastal fisheries of Bangladesh, we see that coastal fisheries are affected by sea level rise in three ways; by salinity, by flooding and by increasing cyclone frequency and damage. These three factors collectively decrease the productivity of coastal fisheries.

Again it revealed in other studies that fisheries are the main protein source for the coastal people of Bangladesh. About 60% to 80% of animal protein intake of the people of Bangladesh comes from fish consumption.[16] So, decreased coastal fisheries would cause protein scarcity among the coastal population that ultimately causes health hazards.

[16] Md Ferdous Alam and Kenneth J. Thomson, "Current Constraints and Future Possibilities for Bangladesh Fisheries," *Food Policy* 26, no. 3 (2001): 298.

Figure 5.4: Causal Loop Diagram of Sea Level Rise Impacts on Coastal Fisheries Sector



Source: H. V. Haraldsson, *Introduction to System Thinking and Causal Loop Diagrams* (2004). Department of Chemical Engineering, Lund University, Lund. Available at https://www.researchgate.net/publication/313405754 accessed 17 January 2017.

Poor health status will gear up poverty in the coastal area. At the same time poverty will boost up health hazards because of lacking sufficient medicine, health care and nutrition. If the coastal fisheries decrease, it will hamper Bangladesh from earning foreign remittance, as because the frozen food industry, the second largest foreign exchange earner sector of Bangladesh, is dependent on coastal fisheries. Insufficient foreign exchange earnings will also increase poverty. Increased poverty will boost up the dependency on foreign aid. Finally it will create economic imbalance among the neighboring countries.

Table 5.8: Loss of Production in Fisheries and Aquaculture

Loss of Production in Fisheries and Aquaculture		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Low	n	13	14	11	21	31	15	105
	%	18.1%	19.4%	19.3%	42.9%	36.9%	32.6%	27.6%
Medium	n	43	48	26	17	28	25	187
	%	59.7%	66.7%	45.6%	34.7%	33.3%	54.3%	49.2%
High	n	16	10	20	11	25	6	88
	%	22.2%	13.9%	35.1%	22.4%	29.8%	13.0%	23.2%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Pearson Chi-Square	Value = 35.405 , df =10, p = .000							

Source: Questionnaire Survey, June-October, 2016

5.4.2 Abiotic Impact

Abiotic factors are the nonliving physical components of an ecosystem. Sea level rise has major impact on abiotic factors. In abiotic stress the impact directly affect the environment and ecosystem are discussed. These are under mentioned

5.4.2.1 Increase of Salinity Intrusion

Salinity intrusion is the main alarming dimension of Sea level rise. It has serious impacts on water resources as fresh water availability is reduced by salinity intrusion. This study finds that 41.3% of the respondents think about the high level problem of salinity intrusion followed by 36.8% and 21.8% as medium and low level problem respectively. Munshigonj, Gabura and Khurushkul union are the most vulnerable as 50.0%, 58.3% and 44.0% respectively according to the perception of the respondents (table 5.11).

A comparative study of the salt affected area from 1973 to 2009 showed that about 0.223 million ha (26.7%) new land is effected by various degrees of salinity during about the last four decades (table 5.9). It was also found that about 35,440 hectares of new land has been affected by various degrees of salinity during last 9 years only (2000-2009).[17]

Table 5.9: The Salt Affected Area from 1973 to 2009 in Coastal Areas

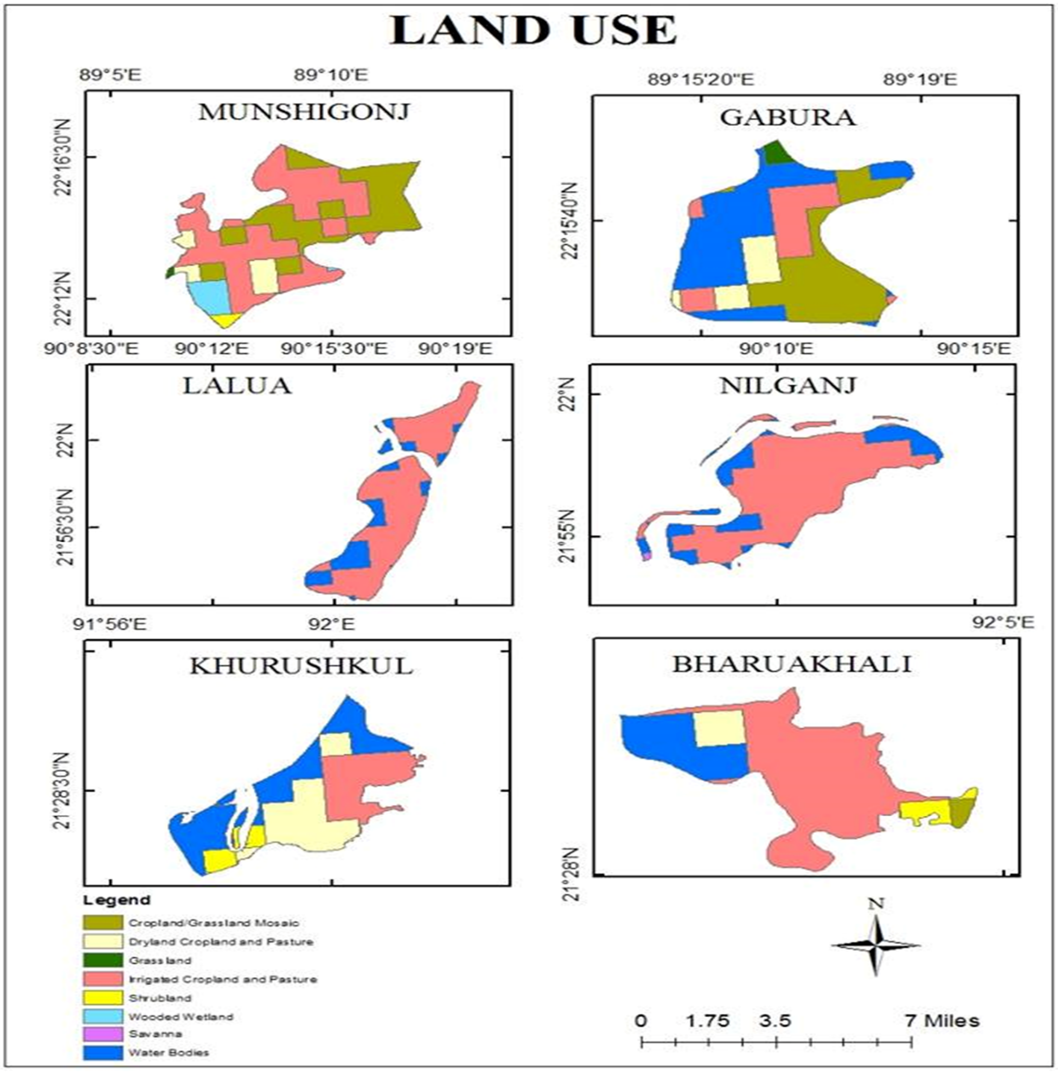
Salt affected area (000'ha)			Salt affected area increased during last 9 years (000'ha) (2000-2009)	Salt affected area increased during last 36 years (000'ha) (1973-2009)
1973	2000	2009	35.51 (3.5%)	222.81(26.7%)
833.45	1020.75	1056.26		

Source: Soil Research Development Institute (SRDI), 2009.

The study shows that soil of southern part of coastline of Bangladesh is being salinized gradually of time expansion. The rate is alarming for the exposed coast area. Jessore, Magura, Narail, Faridpur, Gopalgonj and Jhalokati were newly salinized in 24 years (1997-1997). A one meter sea level rise will expand the soil and water salinity area at a faster rate. Accordingly, this will make a major change in land use pattern.

[17] SRDI, *Saline Soil of Bangladesh*, Ministry of Agriculture, 2010: 5 available at https://www. srdi.portal.gov.bd/sites/srdi/Soil (accessed on 17 March 2016).

Figure 5.5: Land Use Pattern of Study Area



Source: Bangladesh Agricultural Research Council, 2016 (*ArcGIS10*.2.2 Model Map on Land Use Pattern).

Table 5.10: Land Use Pattern of Study Area

Union	Land Use (% Area)								
	Cropland	Pastor	Grass land	Irrigated land	Shrub land	Wet land	Savanna	Water Bodies	Total
Munshigonj	30.2	16.2	0.0	32.3	2.8	19.3	0.0	0.0	100.0
Gabura	36.3	8.8	2.4	12.3	0.0	0.0	0.0	40.6	100.0
Lalua	0.0	0.0	0.0	79.7	0.0	0.0	0.0	20.3	100.0
Nilganj	0.0	0.0	0.0	74.6	0.0	0.0	0.0	25.4	100.0
Khurushkul	0.0	9.5	0.0	21.3	10.2	0.0	0.0	58.9	100.0
Bharuakhali	0.0	7.2	0.0	72.8	0.0	0.0	0.0	20.0	100.0

Source: Bangladesh Agricultural Research Council, 2016.

Both water and soil salinity along the coast will be increased destroying normal characteristics of coastal soil and water with the rise in sea level. Saline intrusion from sea level rise will degrade water quality in coastal rivers, lakes, ponds, and aquifers in different regions of the country. This degradation will in turn put stress on the existing drinking water sources which already a problem is affecting to varying extents. Sea level rise would also aggravate the water quality impacts of cyclones and storm surges, which can spread pollution from contaminated sources. In fact, these extreme events can act as vehicles for transferring water quality risk. More pollution will lead to more waterborne illnesses. Earlier study produced by Soil Resources Development Institute shows that the problem is already on the way.[18]

Table 5.11: Impact Due to Salinity Intrusion

Level of salinity intrusion		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Low	n	9	7	8	18	28	13	83
	%	12.5%	9.7%	14.0%	36.7%	33.3%	28.3%	21.8%
Medium	n	27	23	30	20	19	21	140
	%	37.5%	31.9%	52.6%	40.8%	22.6%	45.7%	36.8%
High	n	36	42	19	11	37	12	157
	%	50.0%	58.3%	33.3%	22.4%	44.0%	26.1%	41.3%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Pearson Chi-Square	Value = 35.623, df =10, p = .000							

Source: Questionnaire Survey, June-October, 2016

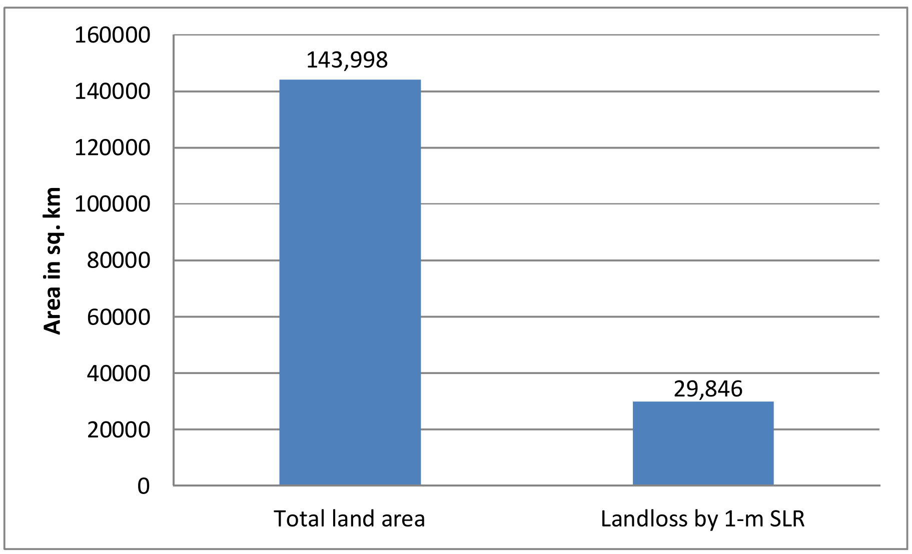
5.4.2.2 Impacts on Landmass Due to SLR

In the present study it reveals a terrible picture about landmass loss by the perception of the respondents of the study area due to SLR. Considering the perception of the respondents 57.4%, 22.4% and 20.3% of total respondents respectively think medium, high and low impact on landmass due to sea level rise. Gabura, Bharuakhali and Munshigonj are the vulnerable union according to their perception as 66.7%, 65.2% and 63.9% respectively (table 5.13).

[18] SRDI Report, "*Soil Salinity in Bangladesh*", Soil Resource Development Institute, Dhaka, 2009 available at www.documents.worldbank.org/curated/en/131161468004833954 */text/WPS7140.txt (accessed on 19 March 2016).*

The result is consistent with previous studies that the increasing rate of SLR will impose its impacts on Bangladesh through the coastal area and gradually on the whole of Bangladesh. About 2,500, 8,000 and 14,000 km of land (with a corresponding percentage of 2%, 5% and 10% with respect to the total land area of the country) will be lost due to SLR of 0.1m, 0.3m and 1.0m respectively.[19] The potential land loss estimated by Fourth Assessment Report of the Intergovernmental Panel on Climate Change is even worse. It reports that 29,846 sq. km area of land will be lost and 14.8 million people will be landless by 1-m SLR.

Figure 5.6: Total Area and Potential Land Loss by 1m SLR



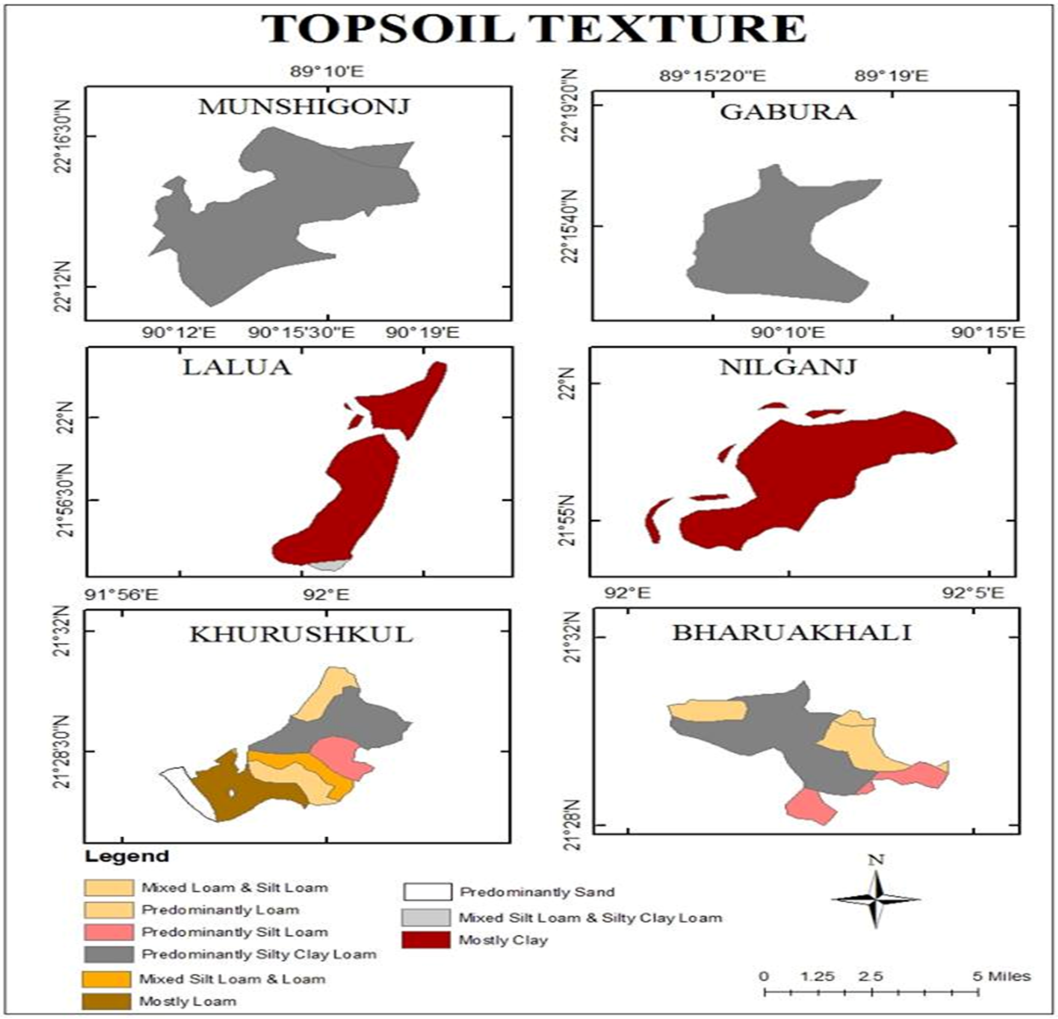
Source: Anwar Ali, "Climate change impacts and adaptation assessment in Bangladesh." *Climate research12*, no 3(1999), 109.

Land loss leads to loss of agricultural land, loss of homestead, loss of road and other communication infrastructure and above all loss of wide range of biodiversity. One of the major causes of land loss is erosion. By raising water level Sea level rise initiates erosion. Raised water level wash out the loose top soil of the coast which makes the coastal region steeper. Back water effect is accelerated by sea level rise that also cause erosion. Silt or other particles eroded from the surrounding areas are deposited when the lowlands of the coastal areas are filled with water. Present soil texture of the study area has been presented in figure 5.7.

---

[19] Anwar Ali, "Climate Change Impacts and Adaptation Assessment in Bangladesh," *Climate Research12*, no 3(1999), 109.

Figure 5.7: Soil Texture of the Study Area



Source: Bangladesh Agricultural Research Council, 2016 (*ArcGIS10*.2.2 Model Map on Top Soil Texture Status).

Table 5.12: Present Top Soil Texture Status in Study Area

Union	Top Soil Texture (% Area)								
	Silty Clay Loam	Loam	Silt Loam	Sand	Clay	Clay Loam	Sandy Loam	Mixed	Total
Munshigonj	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Gabura	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Lalua	0.0	0.0	0.0	6.7	93.3	0.0	0.0	0.0	100.0
Nilganj	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0
Khurushkul	8.9	5.5	19.1	10.9	22.8	28.2	4.5	11.1	100.0
Bharuakhali	47.1	0.0	21.9	0.0	0.0	9.8	0.0	21.2	100.0

Source: Bangladesh Agricultural Research Council, 2016.

Potential sea level rise will play important role in erosion processes in the coastal zone. Most vulnerable shore types to sea level rise are sandy and silty shore. Coastal areas of Bangladesh are formed of silty and sandy soils which make them vulnerable to sea level rise. Sandy and silty shores are easily eroded by sea level rise. Munshigonj and Gabura Unions are the most vulnerable for future event of SLR. It is stated that sea level rise of 1.0 metre will cause an erosion of a sandy shore in the order of 100-500 metre. Erosion rate due to sea level rise along the Bangladesh coast is increasing rapidly.

Mangrove forest with net-like spread root system acts as coastal stabilizer and binder that protect soil erosion in the coastal area. Salinity intrusion will harm mangrove forest of the area. Decreased mangrove will result in breaking soil composition. Thus sea level rise will accelerate soil erosion in the coastal area by reducing mangrove forest.

Table 5.13: Impact on Landmass Due to SLR

Impact on Landmass		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Low	n	11	14	6	15	21	10	77
	%	15.3%	19.4%	10.5%	30.6%	25.0%	21.7%	20.3%
Medium	n	46	48	31	23	40	30	218
	%	63.9%	66.7%	54.4%	46.9%	47.6%	65.2%	57.4%
High	n	15	10	20	11	23	6	85
	%	20.8%	13.9%	35.1%	22.4%	27.4%	13.0%	22.4%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Pearson Chi-Square	Value = 20.910[a], df =10, p = .022							

Source: Questionnaire Survey, June-October, 2016

5.4.2.3 Impacts on Settlement

The future event of SLR will cause immense damage to the coastal settlement. The study finds that 27.1% of respondents think about the high possibility of damage of settlement followed by 52.1%, 20.8% as medium and low possibility of damage of human settlement. In higher possibility of damage of settlement is found in Bharuakhali, Lalua and Khurushkul hold as 52.2%, 36.8% and 26.2% respectively (table 5.14). The result is similar to the earlier studies that sea level rise will increase morphological activities in the river, inducing increased river flow. Accelerated river flow will increase river bank erosion too and this will affect the settlement.[20]

[20] David Hutton, and C. Emdad Haque, "Patterns of Coping and Adaptation among Erosion-Induced Displaces In Bangladesh: Implications for Hazard Analysis and Mitigation," *Natural Hazards* 29, no. 3 (2003): 406.

The predicted land erosion will cause immense displacement of coastal population. Most of the poor people do not have land of their own. In some cases they only have a small piece of land to build a cottage to live in. Once the home is eroded, they become homeless, something like refugees in their home country. When they build a new house, it is eroded after a couple of years. Then they move to a nearby area and set up another house which is also eroded after some years. Different studies observed that people even displaced ten times due to erosion. River bank erosion of the Jamuna River is very important example for population displacement.[21] Thus, erosion will cause financial loss for the displace people to build their new houses.

Table 5.14: Impact on Human Settlements Due to SLR

Damage of Human Settlements		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Low Possibility	n	15	13	14	11	17	9	79
	%	20.8%	18.1%	24.6%	22.4%	20.2%	19.6%	20.8%
Medium Possibility	n	49	43	22	26	45	13	198
	%	68.1%	59.7%	38.6%	53.1%	53.6%	28.3%	52.1%
High Possibility	n	8	16	21	12	22	24	103
	%	11.1%	22.2%	36.8%	24.5%	26.2%	52.2%	27.1%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Pearson Chi-Square	Value = 32.372[a], df =10, p = .000							

Source: Questionnaire Survey, June-October, 2016

5.4.2.4 Impacts on Salt Farming

Salt producing industry is one of the main sources of livelihood in coastal zone of Bangladesh. Bangladesh is also famous country in the world as salt producing industry. Cox's Bazar coast of Bangladesh coastline is suitable for salt production which is also included in the study area.[22] About 19,670 ha area has been used for salt production along the Cox's Bazar coast of the country. There are 216 salt plants, having an area of 8,153 ha only in Chakaria and Cox's Bazar Sadar thana of the district, producing 175,030 metric tons of salt annually.[23] Climatic variability affects the whole process of salt

[21] M R Rahman, "Impact of Riverbank Erosion Hazard in the Jamuna Floodplain Areas in Bangladesh," J. Sci. Foundation 8, no. 1&2(2010): 55-65. Available at *www.banglajol.info/ index.php/JSF/article/ download/14627/10382* accessed 23 October 2016.

[22] *Impacts of Sea Level Rise on the Coastal Zone of Bangladesh*, Available at *http://www.pg-du.com/wp-content/uploads/2012/02/golam_sarwar.pdf* accessed 25 October 2016.

[23] M.S. Hossain, and C.K. Lin, "Land Use Zoning for Integrated Coastal Zone Management: Remote Sensing, GIS and PRA Approach in Cox's Bazar Coast, Bangladesh," *ITCZM* (Asian Institute of Technology, Thailand.) *Monograph* No.3 (2001): 19.

manufacturing system. It is found in the field study through interview and FGD that the total coastal salt industry is fully influenced by sea water and its level.

To produce salt, sea water is collected from nearby canal or river and stored in the reservoir. After three days brine is transferred into the condenser. Again, after three days dense brine is transferred into the crystallizer. Transferring time (i.e. 3 days) may vary upon the evaporation rate that is influenced by sunshine, wind speed and humidity. Salt crystals are supplied to salt mill owners where washing, crushing, iodine mixing and packaging is done. All the activities of salt production that are handled by salt farmers (i.e. activities in reservoir, condenser and crystallizers) are performed in the close area of the coastline. Moreover, salt mills are also located very close to the coastline. A one metre sea level rise will inundate all the salt fields and will ruin the sectors. Salt farmers can't move upwards land for the purpose because, physical properties of the soil of the present salt field will not move backwards with sea level rise. About 20 million people are directly or indirectly related in salt production and salt trading in Bangladesh.[24] Sea level rise, by inundating salt fields will force this huge number of people to be unemployed. This large population will try to find alternative profession, which is very hard or even impossible, in the case of present situation of Bangladesh.

5.4.2.5 Impacts on Ecological Unit

To find out the impacts on ecological unit respondents were interviewed about the impact on ecological unit. The respondents replied about their perception of impact on ecological unit due to sea level rise. More than 50% respondents think about the high level impact on ecological unit. More than 30% respondents think about the medium impact on ecological unit due to sea level rise. From their views it is found that Munshigonj, Lalua and Bharuakhali are the vulnerable Union regarding sea level rise (table 5.16).

This finding admits the previous study that the Sundarbans is the main ecological unit in the coastal zone of Bangladesh. The Sundarbans mangrove forest is the world's biggest unique portion of mangrove forest, located at the south of the tropic of cancer, the southwest part of Bangladesh, covering part of Khulna, Satkhira and Bagerhat district. The area of the Sundarbans varies each year because of soil erosion or land accretion.

[24] Md Shahadat Hossain, "Biological Aspects of the Coastal and Marine Environment of Bangladesh," *Ocean & Coastal Management* 44, no. 3 (2001): 264.

However, its present area in Bangladesh part is 6,500 square kilometer.[25] The Sundarbans is very rich in biodiversity. Area of the Sundarbans, inundated by different scale of sea level rise is shown in the Sea level rise will cause rise in the salinity concentration in the water and soil of the Sundarbans. The site is shelter to a number of unique and globally or nationally endangered species of plants like rare Sundari, Gewa, Passur, animals etc. Increased salinity will change the habitat pattern of the forest. Sundari, the most dominating trees of the Sundarbans is thought to suffer from Top dyeing disease because of increased salinity.[26] The Sundarbans is also a habitat of some important species like-Wild boar, spotted deer, Barking deer, Rhesus macaque, Jungle cat, Leopard cat, Otter, Squirrels and the Indian porcupine. The forest also supports habitat to marine turtles, crocodiles, frogs, and fresh water dolphins.

Table 5.15: Fate of the Sundarbans with Different Scenarios of Sea Level Rise

SLR (m)	Inundation of Sundarbans (%)
0.10	15
0.25	40
0.45	75
0.60	100
1.0	Total destruction

Source: World Bank. *Bangladesh: Climate Change & Sustainable Development*. Report No. 21104 (2000) BD, Dhaka.

The Sundarbans will be completely lost with 1 metre sea level rise. Loss of the Sundarbans means great loss of heritage, loss of biodiversity, loss of fisheries resources, loss of life and livelihood and after all loss of very high productive ecosystem. With the loss of the Sundarbans, habitat of these species would also be lost. Recognizing the regular exhaustion of ecosystems and the ecological importance of the flora and fauna, Bangladesh has identified protected areas in the form of national parks, game reserves, wildlife and fish sanctuaries, World Heritage sites, Ramsar sites, marine reserves and ecologically critical areas (Appendix table 11).[27]

[25] A. H. M. R. Haq, Tapan Kumar Ghosal and Pritam Ghosh, "Cultivating Wetlands in Bangladesh," *Leisa Magazine* 20, no. 4 (2004): 18.

[26] Md Shahadat Hossain, "Biological Aspects of the Coastal and Marine Environment of Bangladesh," *Ocean & Coastal Management* 44, no. 3 (2001): 265.

[27] M. S. Islam, "Perspectives of the Coastal and Marine Fisheries of the Bay of Bengal, Bangladesh," *Ocean & Coastal Management 46,* no. 8 (2003). 763.

Table 5.16: Impacts on Ecological Unit

Impacts on Ecological Unit		Study Villages						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Low	n	7	6	5	9	11	10	48
	%	9.7%	8.3%	8.8%	18.4%	13.1%	21.7%	12.6%
Medium	n	20	30	17	18	25	11	121
	%	27.8%	41.7%	29.8%	36.7%	29.8%	23.9%	31.8%
High	n	45	36	35	22	48	25	211
	%	62.5%	50.0%	61.4%	44.9%	57.1%	54.3%	55.5%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Pearson Chi-Square	Value = 12.968[a], df =10, p = .015							

Source: Questionnaire Survey, June-October, 2016

5.4.2.6 Increasing Natural Disaster

There is linkage between the increasing disasters and climate change. From present discussion it is found SLR triggers up other disasters. Coastal people's perception is the important tool to assess the frequency of disaster takes place in the coastal area. About 50% of the respondents agreed that potential impact of sea level rise will increase other disasters such as landslides and tsunamis. Nearly one-third of the respondents think that the increase rate of disaster is medium. Lalua and Bharuakhali unions are the vulnerable unions as nearly 55% and 58% of the respondents think high possibilities of natural disasters due to SLR (table 5.17).

The drastic weather events that can happen because of melting polar ice caps and glaciers and rising sea level include an increase in the number of landslides and tsunamis felt around the world. Recently a number of natural disasters have taken place in Bangladesh such as Sidr, Aila, and Nargis. Rising sea level will cause water to mix with sea water, thereby making once potable freshwater drinking sources no longer available for human consumption. Moreover, rising sea levels has also been linked to other devastating side effects, such as an increase in earthquakes and other major seismic events.

Table 5.17: Increase of Natural Disaster Due to SLR

Increase of Natural Disaster		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Low Increase	n	11	17	10	10	13	5	66
	%	15.3%	23.6%	17.5%	20.4%	15.5%	10.9%	17.4%
Medium Increase	n	25	21	16	17	32	14	125
	%	34.7%	29.2%	28.1%	34.7%	38.1%	30.4%	32.9%
High increase	n	36	34	31	22	39	27	189
	%	50.0%	47.2%	54.4%	44.9%	46.4%	58.7%	49.7%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Pearson Chi-Square	Value = 6.452, df =10, p = .000							

Source: Questionnaire Survey, June-October, 2016

5.4.2.7 Increasing Intensity of Monsoon Flooding

Considering the climate change scenario in the coastal zone of Bangladesh about 18 per cent of current lowly flooded areas are susceptible to higher levels of flooding. Moreover, about 12 to 16% new areas will be at risk of varied degrees of inundation. As per NAPA recommendations, SLR will happen in the coast of Bangladesh at 14 cm, 32 cm and 88 cm for the year 2030, 2050 and 2100. In a recent study, it has been predicted that flooding of coastal lands may increase by 21% by the year 2020 while it is 10.3% for the year 2050 with respect to ordinary flooding condition when approximately 50% lands go under flood.[28] SLR will increase the intensity of monsoon flooding. As the near 34% of the respondents think it is devastating whereas near about 56% respondents think it is moderate and 11.1% consider that there might have a low intensity of monsoon flooding (table 5.18).

[28] IWM. *Sundarbans Biodiversity Conservation Project: Surface Water Modeling*, Final Report (2003). Institute of Water Modeling, Ministry of Environment and Forests, Government of Bangladesh.

Table 5.18: Monsoon Flooding Due to Sea Level Rise

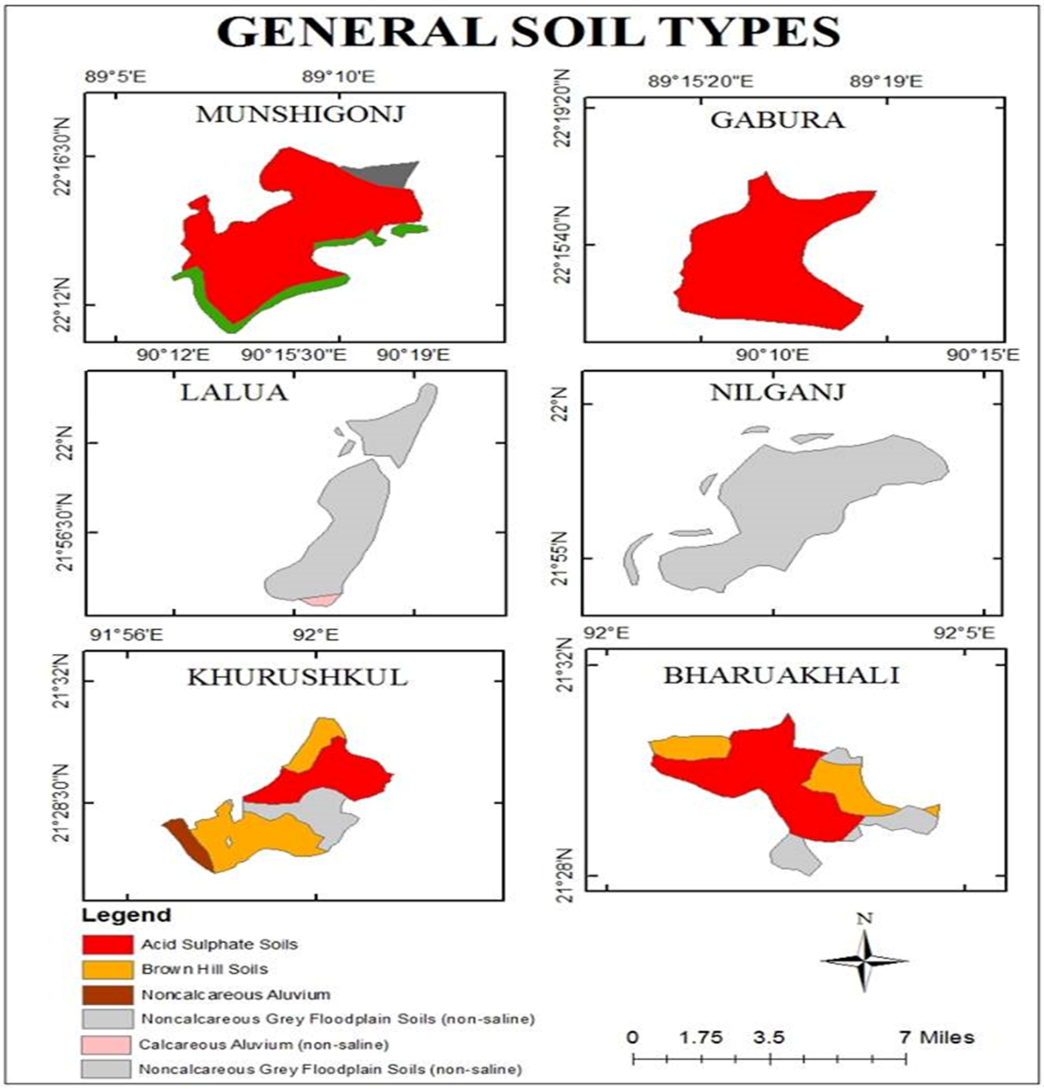
Monsoon flooding		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Low Intensity	n	4	2	7	13	10	6	42
	%	5.6%	2.8%	12.3%	26.5%	11.9%	13.0%	11.1%
Moderate Intensity	n	52	53	31	24	36	16	212
	%	72.2%	73.6%	54.4%	49.0%	42.9%	34.8%	55.8%
High Intensity	n	16	17	19	12	38	24	126
	%	22.2%	23.6%	33.3%	24.5%	45.2%	52.2%	33.2%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Pearson Chi-Square	Value = 45.916, df =10, p = .000							

Source: Questionnaire Survey, June-October, 2016

5.4.2.8 Declining Soil Quality

The respondents of the study area were interviewed about perception of the possible impact of declining soil quality. About 44% of the respondents think for high level impact whereas 34% think for medium level of impact of regarding the decline of soil quality. Bharuakhali, Nilgonj and Lalua unions are the vulnerable areas as per the perception of the respondents about declining soil quality by sea level rise. Respondents of Bharuakhali, Lalua and Gabura think comparatively devastating trend of soil quality degradation due to sea level rise as 63.0%, 61.4% and 50.0% respectively (table 5.20). Sea level rise induced salinity intrusion will decline soil quality of coastal zone. The present status of general soil type is presented in figure 5.8.

Figure 5.8: General Soil Type of Study Area



Source: Bangladesh Agricultural Research Council, 2016 (*ArcGIS10*.2.2 Model Map on General Soil Type).

Table 5.19: General Soil Types in Study Area

Union	General Soil Types (% Area)					
	Acid Sulphate	Brown Hill	Noncalceous Alluvium	Calceous Alluvium	Noncalceous Grey	Total
Munshigonj	82.9	0.0	6.8	0.0	11.3	100.0
Gabura	90.0	0.0	0.0	0.0	10.0	100.0
Lalua	0.0	0.0	96.5	3.5	0.0	100.0
Nilganj	0.0	0.0	100.0	0.0	0.0	100.0
Khurushkul	22.1	0.0	27.9	33.4	16.6	100.0
Bharuakhali	54.6	0.0	0.0	12.5	32.9	100.0

Source: Bangladesh Agricultural Research Council, 2016.

The soil profile of the affected area is totally changing and this situation led to unproductive land. It reveals that acid sulphate base soil is increasing rapidly due to salinity. The soil profile is also changing which has a devastating effect on coastal areas. Potential impact of sea level rise has impact on the degradation of soil quality.

Table 5.20: Decline in Soil Quality Due to Sea Level Rise

Decline in Soil Quality		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Low	n	12	13	10	8	31	7	81
	%	16.7%	18.1%	17.5%	16.3%	36.9%	15.2%	21.3%
Medium	n	31	23	12	22	31	10	129
	%	43.1%	31.9%	21.1%	44.9%	36.9%	21.7%	33.9%
High	n	29	36	35	19	22	29	170
	%	40.3%	50.0%	61.4%	38.8%	26.2%	63.0%	44.7%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Pearson Chi-Square	Value = 35.623, df =10, p = .000							

5.4.2.9 Species Extinction

It is predicted that sea level rise can cause to destroy the forest, land, fresh water resource, and living environment of coastal areas. As a result some species may extinct in the coastal zone. Furthermore, species extinction may lead to destroy the traditional biodiversity in the coastal areas of Bangladesh which has a greater environmental cost.

5.4.2.10 Coastal Erosion

Coastal erosion is another negative impact of sea level rise. About 29.5% respondents think high level of erosion, 47.9% of the respondents think moderate level of erosion where as 22.6% of the respondents think about slow erosion of sea level rise. Considering the erosion trend of sea level rise the highest respondents are Khurushkul, Gabura and Lalua as 45.2%, 34.7% and 33.3% respectively. According to their perception these unions would have coastal erosion due to sea level rise (table 5.21).

Table 5.21: Coastal Erosion Due to Sea Level Rise

Coastal Erosion Adversity		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Slow	n	20	13	20	14	16	3	86
	%	27.8%	18.1%	35.1%	28.6%	19.0%	6.5%	22.6%
Moderate	n	43	34	18	31	30	26	182
	%	59.7%	47.2%	31.6%	63.3%	35.7%	56.5%	47.9%
High	n	9	25	19	4	38	17	112
	%	12.5%	34.7%	33.3%	8.2%	45.2%	37.0%	29.5%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Likelihood Ratio	Value = 46.450, df =10, p = .000							

Source: Questionnaire Survey, June-October, 2016

The major factors of coastal erosion in Bangladesh include Strong tidal action and storm surges, High wind waves and current during monsoon, and high river discharge (central coastal zone). There are no accurate measurements on coastal erosion due to SLR. However, many researchers estimated the potential impacts of SLR on erosions. For example, Islam predicted that average recession of the eastern coastline of Bangladesh would be about 87 times for the SLR.[29] If that is true then the land loss is given as

Table 5.22: Coastal Erosion Due to Sea Level Rise in Different Situation

Sea Level Rise	Amount of Land Area to be Eroded
SLR of 0.1 m	6.26 sq. km
SLR of 0.3 m	18.79 sq. km
SLR of 1.0 m	62.64 sq. km

Source: M. S. Islam, "Perspectives of the Coastal and Marine Fisheries of the Bay of Bengal, Bangladesh," *Ocean & Coastal Management 46,* no. 8 (2003). 764.

5.4.2.11 Increasing of Water Logging

As the height of the sea level increases the saline water would enter into the inland village and because low lying area the entered water would not pass away. This will create water logging in interior part of the coastal area. About 64% of the respondents think higher possibility of water logging due to sea level rise, 18.7% of the respondents think medium water logging due to sea level rise. Bharuakhali, Khurushkul and Nilgonj unions are the vulnerable of water logging as per the percentage of the perception of the respondents as 91.3%, 73.8% and 69.4% respectively.

[29]M. S. Islam, "Perspectives of the Coastal and Marine Fisheries of the Bay Of Bengal, Bangladesh," *Ocean & Coastal Management 46,* no. 8 (2003). 764.

In the coastal region of Bangladesh water logging is a major problem as it was first started during 1960 after the construction of coastal polders (dikes) with sluice gates controlling river flows and to protect low-lying agricultural lands from tidal inundation and saline water intrusion. After the construction of polders, the silt was deposited on the river beds, resulting in the silting up of rivers. Eventually, the exit points of the sluice gates became blocked, and subsequently, the emboldened areas became permanently water logged.

Table 5.23: Water Logging Due to Sea Level Rise

Water logging		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Low Possibility	n	19	15	10	3	6	0	53
	%	26.4%	20.8%	17.5%	6.1%	7.1%	0.0%	13.9%
Medium Possibility	n	10	13	16	12	16	4	71
	%	13.9%	18.1%	28.1%	24.5%	19.0%	8.7%	18.7%
High Possibility	n	43	44	31	34	62	42	256
	%	59.7%	61.1%	54.4%	69.4%	73.8%	91.3%	67.4%
Total	N	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Likelihood Ratio	Value= 41.739, df= 20, p=.000							

Source: Questionnaire Survey, June-October, 2016

5.4.3 Socio-Economic Impact of Sea Level Rise

Socio-economic impact is different from environmental impact. Climate change induced sea level rise has serious impact on socio-economic perspective. Here emphasize is given to scrutinize the socio economic vulnerabilities of coastal areas of Bangladesh due to environmental impact of SLR. There are nineteen coastal districts in Bangladesh which are on high risky position in terms of socio economic vulnerability due to Sea level rise. According to BBS, 2011 there are 35.1 million people are living in the coastal areas are Bangladesh which are counted as 28% of total population size of the country. The economic activities of coastal zone are circulated by fishing, agriculture, salt farming and shrimp cultivation. These economic activities are fully dependent on natural resources and environmental sustainability. Any changes in environmental behavior can bring a significant impact on coastal economy and its associated stakeholders. In this section the socio economic parameters like security, infrastructure, climate refugee, GDP, education, poverty , natural resources, social welfare etc. of coastal zone that can be affected by the Sea level rise has been highlighted for economic analysis.

5.4.3.1 Impacts on Basic Needs

In the context of SLR induced impact on basic needs, the respondents of the study were interviewed about the impact of basic need security. About 48% of the respondents think there is possibility of impact whereas about 38% agree about the higher possibility of impact about 15% of the respondents think it would happen or not. Bharuakhali, Lalua and Nilgonj union are the highest vulnerable regarding the impact of basic need by sea level rise as 65.2%, 45.6% and 44.9% respectively (table 5.25).

The findings are similar to earlier literature. It is mentioned that security in a general sense is the condition of being protected from or not exposed to danger. Anything or occurrence that hurt human being, directly or indirectly is a security threat.[30] Sea level rise, by reducing fresh water availability, reducing fisheries and agricultural production, eroding coastal land, losing biodiversity and by causing health hazards creates a danger situation for the people of Bangladesh. Again, basic needs are the most important things for survival of human being.

Food, clothing, housing, health and education are the basic needs of the people of Bangladesh. The given table explains how sea level rise affects the basic needs of large number of people of the country (table-5.24). Affecting basic needs, sea level rise becomes a threat to food security and other well-being securities.

[30] Jon Barnett, "Security and Climate Change," *Global Environmental Change* 13, no. 1 (2003): 11.

Table 5.24: Impacts of Sea Level Rise on the Basic Needs

Basic needs	How sea level rise affects
Food	Rise in sea level would flood agricultural lowlands and deltas in parts of Bangladesh that will decrease food production, causing shortage of food. Only salinity intrusion due to sea level rise will reduce 0.2 million metric ton of rice production.[31]
Cloths	Sea level rise will increase poverty. Increased poverty will decrease cloths buying capacity of the people of Bangladesh
Housing	In Bangladesh, 29,846 sq. km. area of land will be lost and 14.8 million people will be landless by sea level rise, losing their house.[32]
Health	Sea level rise by extending coastal area and by increasing salinity in the area will increase the risk of cholera. It will accelerate flood intensity facilitating transmission of diarrheal disease.
Education	Sea level rise will cause destruction of infrastructure including educational institutes. Besides, students of flood, or other sea level rise affected family will leave school/ college, in search of work to support their family.

Source: Md.Lokman Hossain and Mohammad Kamal Hossain, *Climate Change, Sea Level Rise and Coastal Vulnerabilities of Bangladesh with Adaptation Options* available at www.academia.edu/1224958/climate_change_sea_level_rise_and_coastal (accessed 11 September 2016).

Another study explains that 'ecosystem people' are locally based populations who use their own labor to survive by cultivating and harvesting food and other resources from specific localities.[33] Many of these people have been displaced from their homes in recent decades becoming 'ecological refugees'. Sea level rise will create such ecological or environmental refugees in the country, forming 'ecological marginalization'. It states that 5.5 million people living on the Ganges delta in Bangladesh who will be forced to relocate with a 45 cm rise in sea level may seek to move inland within Bangladesh.[34]

A study of Earth Policy Institute shows the problem more seriously, that about 40 million people of Bangladesh out of whole population will become environmental refugees due to 1m sea level rise.[35] Different environmental problem including sea level rise will prompt mass migration, and in turn, stimulate group conflicts. There is a long term conflict between Bangladesh and India, regarding the distribution of water of the Ganges River,

[31] www.academia.edu/1224958/climate_change_sea_level_rise_and_coastal (accessed on September 11, 2016).

[32] https://www.weadapt.org/knowledge-base/national-adaptation (accessed on October 14, 2016).

[33] S. Dalby, "Environmental Change and Human Security," *ISUMA*, 2000:73.

[34] Jon Barnett, "Security and Climate Change," *Global Environmental Change* 13, no. 1 (2003): 10.

[35] Earth policy Institute, "Increased Flows of Environmental Refugees," EDC News, available at http: //www.edcnews.se/cases/EnvRefugeesBrown.html., (accessed on October 17, 2016).

refugees and other issues.[36] Environmental refugees created by sea level rise will cause even worse situation that may trigger conflict between the two countries. Thus, sea level rise might be a threat to basic need and national security of Bangladesh.

Table 5.25: Impact on Basic Needs Due to Sea Level Rise

Impact on Basic Needs		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Less possibility	n	14	17	7	3	14	0	55
	%	19.4%	23.6%	12.3%	6.1%	16.7%	0.0%	14.5%
Medium Possibility	n	44	42	24	24	32	16	182
	%	61.1%	58.3%	42.1%	49.0%	38.1%	34.8%	47.9%
High Possibility	n	14	13	26	22	38	30	143
	%	19.4%	18.1%	45.6%	44.9%	45.2%	65.2%	37.6%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Likelihood Ratio	Value= 56.578, df= 20, p=.000							

Source: Questionnaire Survey, June-October, 2016

5.4.3.2 Impact on Infrastructure

Development of socio-economic status depends on the basic infrastructure of the region. Road network is the important part of infrastructure. There are 35,712 kilometers established roads in the coastal zone. Every year natural disaster causes to destroy a tremendous part of roads. Besides, bridge, culvert, embankment are also harmed. Repairing and reconstruction cost of this sort of infrastructure is high. Sea side ship-breaking industries, tourist spot, public & private infrastructure will also be damaged due to sea level rise. Our most important tourist attraction Cox's bazar, kuakata, St .Martin, Sundarbans will be adversely affected by the sea level rise. Near future tourist business will lose revenue from these areas. The people those who are employed in tourist sector in the coastal zone will be in risk on massive job lose.

5.4.3.3 Emergence of Climate Refugee

According to IPCC 2007, 1 meter rise in sea level will lead to go down most of the part of southern and western region of Bangladesh under water. As a result, 3 crore of people from coastal part of Bangladesh will be deadly affected. They will lose their land and living place. More than 20 million people will be climate refugee due to sea level rise.[37] These people will create chaos in the city or nearby town and city may not properly

[36] Ainun Nishat and Islam M. Faisal, "An Assessment of the Institutional Mechanisms for Water Negotiations in the Ganges-Brahmaputra-Meghna System," *International Negotiation* 5, no. 2 (2000): 291.

[37] Md Modasser Hossain Khan, Ian Bryceson, Korine N. Kolivras, Fazlay Faruque, M. Mokhlesur Rahman, and Ubydul Haque, "Natural Disasters and Land-Use/Land-Cover Change in the Southwest Coastal Areas of Bangladesh," *Regional Environmental Change* 15, no. 2 (2015): 244.

accommodate this huge amount of displaced people. The coastal people positively answered about the incident of increasing climate refugee. About 50% of the respondents think that there is higher possibility of happening climate refugees; about 28% of the respondents think medium possibility whereas about 23% think low level of possibility about climate refugees. Another point is clearly found here that the interior respondents think about the higher possibility of climate refugees because coastal attached people will be affected first and they will be replaced to the interior land and it is very consistent with the previous discussion.

Table 5.26: Emergence of Climate Refugee

sea level rise refugee		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Less Possibility	n	11	18	11	10	22	17	89
	%	15.6%	25.0%	19.3%	20.4%	26.2%	37.0%	23.4%
Medium Possibility	n	23	25	20	12	20	5	105
	%	31.9%	34.7%	35.1%	24.5%	23.8%	10.9%	27.6%
High Possibility	n	38	29	26	27	42	24	186
	%	52.8%	40.3%	46.6%	56.1%	50.0%	52.2%	49.0%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Pearson Chi-Square	Value= 58.941, df= 20, p=.000							

Source: Questionnaire Survey, June-October, 2016

5.4.3.4 Loss of GDP and Appearance of Macroeconomic Stress

This study finds about the macroeconomic stress from the perception of the respondents of the study area. About 43% of the respondents think that there is high level of impact on GDP due to SLR, about 39% of the respondents think there is moderate impact on GDP and 17.6% of the respondents think low level of impact on macro economy due to SLR. Comparatively Cox's bazar zone contributes higher than other two zones and the present study finds that the respondents think high level impact due to SLR (table 5.29).

The findings justify IPCC, 2007 that just 1 meter rise in sea level will cause to go down 22,000 square kilometers land under water, which is 16% of our total land area. In this circumstance we will lose our agricultural and industrial production form these areas. According to WB 2000, 1 meter rise in sea level will lead to reduce the rice production by half. This consequence will trigger food inflation and food insecurity in the economy.[38]

[38] World Bank, Bangladesh*: Climate Change & Sustainable Development*, Report No. 21104 (2000) BD, Dhaka.

Table 5.27: National Damage Estimation for Sea Level Rise

Direct Impact		Sea Level Rise Scenario			
		0.1 m SLR	**0.25 m SLR**	**0.3 m SLR**	**1 m SLR**
National damage (in million BDT)		14779.07	28833.64	40160.86	93412.9
Total area inundated due to SLR (in sq. Km)		2500	6300	8000	25000
Affected Sectors (damage in million BDT)	Agriculture	14779.07	28833.64	40160.86	87002.14
	Industry	N/A	N/A	N/A	23 (salt industry of Cox's Bazar)
	Construction	N/A	N/A	N/A	6387.76
Regional inundated area (in sq km)	West Zone	1001.18	2522.98	3203.78	7616.13
	Central Zone	1090.13	2747.13	3488.42	13297
	East Zone	408.69	1029.89	1307.8	4086.87

Source: Adopted from Sarwar Jahan, available at *http://www.buet.ac.bd/iwfm/climate/report/Component_ 5.pdf, 2005 accessed* 11 January, 2017

Regional damages due to extreme scenarios are calculated from national damage figures multiplied by regional share of damage for respective regions where, regional share of damage for a region is equal to the ratio of area affected in that region for a certain scenario to the national affected area for that scenario. This is shown in table 5.28 for West, Central and East regions in agriculture sector and the damage is consistent with the SLR.

Table 5.28: Regional Damage for SLR of 0.1m, 0.25m, 0.3m and 1.0m (in million BDT)

	Share of Damage & Damage to sectors	National	Million BDT(Region wise)		
			West Zone	Central Zone	East Zone
SLR 0.1 m	Share of Damage	1.00	0.40	0.44	0.16
	Agriculture	14779.07	5911.63	6502.79	2364.65
SLR 0.25 m	Share of Damage	1.00	0.40	0.44	0.16
	Agriculture	28833.64	11533.46	12686.80	4613.38
SLR 0.3 m	Share of Damage	1.00	0.40	0.44	0.16
	Agriculture	40160.86	16064.34	17670.78	6425.74
SLR 1.0 m	Share of Damage	1.00	0.31	0.53	0.16
	Agriculture	87002.14	26970.66	46111.13	13920.34

Source: Adopted from Sarwar Jahan, available at *http://www.buet.ac.bd/iw fm/climate/report/Component_5.pdf, 2005 accessed* 11 January, 2017

The scenario is alarming and it will create macro-economic stress of natural resource based e country like Bangladesh. According to MoE, for the consequences of climate change right now we are losing 1.81% GDP annually after 2030 we will lose more than 2.5% of our GDP. This sort of economic loss will cause to emerge macroeconomic stress.

Table 5.29: Loss of GDP and Occurrence of Macroeconomic Pressure

Loss of GDP		Study unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Low	n	14	14	6	9	16	8	67
	%	19.4%	19.4%	10.5%	18.4%	19.0%	17.4%	17.6%
Moderate	n	33	35	32	20	16	12	148
	%	45.8%	48.6%	56.1%	40.8%	19.0%	26.1%	38.9%
High	n	25	23	19	20	52	26	165
	%	34.7%	31.9%	33.3%	40.8%	61.9%	56.5%	43.4%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Pearson Chi-Square	Value= 32.759 , df= 20, p=.000							

Source: Questionnaire Survey, June-October, 2016

5.4.3.5 Impact on Education System

Due to Sea level rise different natural disasters i.e. tsunami, cyclone, flood, tidal upsurge, water logging will be frequent. As a result educational institutions near to coastal area get flooded or ruined and remain closed until reconstruction. Most of the time educational institution those are not affected by natural disaster and these are turned into shelter place for the affected people. Furthermore, due to natural calamity affected students are unable to attend classes. Consequently, education system collapse in coastal area. On the other hand natural disaster breaks up social safety net of affected region. People become poor. Death toll of earning person of a household by the natural disaster bound student to do work for survival. Which lead termination of education life of a child. This situation will be more intensive in future when natural disaster will be more frequent and huge amount of land will go under water by the sea level rise. So, in upcoming time education system will be hampered magnificently in coastal reason, which will imply higher level of socio-economic cost. The present study finds from the perception of the respondents that SLR will seriously affect the educational institutions situated near by the sea. About 36% of the respondents think that the risk is higher, 47% think that the risk is moderate and 16.8% of the respondents think that the impact is low level category. From their perception it is seen in the study that Bharuakhali, Lalua, Khurushkul and Nilgonj union are the most risky area as 52.2%, 45.6%, 45.2% and 44.9% of the respondents agree about the matter from the experience of previous climatic disastrous events.

Table 5.30: Impact on Education System due to Sea Level Rise

Risk on Education		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Low Risk	n	14	17	7	6	14	6	64
	%	19.4%	23.6%	12.3%	12.2%	16.7%	13.0%	16.8%
Medium Risk	n	44	42	24	21	32	16	179
	%	61.1%	58.3%	42.1%	42.9%	38.1%	34.8%	47.1%
High Risk	n	14	13	26	22	38	24	137
	%	19.4%	18.1%	45.6%	44.9%	45.2%	52.2%	36.1%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Pearson Chi-Square	Value= 32.077 , df=10, p=.000							

Source: Questionnaire Survey, June-October, 2016

5.4.3.6 Appearance of Climate Poverty

In the context of climate poverty, the respondents were interviewed and Bharuakhali, Gabura and Lalua areas were found the most vulnerable zone regarding climate poverty as responses were 91.3%, 88.9% and 87.7% respectively. The people these areas are totally natural resource dependent and findings are consistent because destroy of natural resource will accelerate the rate of poverty. This is consistent to other studies as we know due to sea level rise 19 districts of Bangladesh are very much vulnerable. Consequently, inhabitants of coastal zone will lose their resources. Farmer, fisherman, salt producer will lose their profession and earning source. A large number of people will not find any suitable work. Some of them will choose to work in informal sector to survive. There are about 6.8 million households in the coastal zone of which 52 percent are absolute poor.[39] The respondents were interviewed to know their perception about the increasing of poverty rate due to sea level rise and it was found that about 77.9% of the respondents replied positively of increasing of poverty due to sea level rise.

[39] M. S. Islam, "Perspectives of the Coastal and Marine Fisheries of the Bay of Bengal, Bangladesh," *Ocean & Coastal Management 46,* no. 8 (2003). 765.

Table 5.31: Increase of Poverty Rate due to Sea Level Rise

Increase in Poverty Rate		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Yes	n	55	64	50	35	50	42	296
	%	76.4%	88.9%	87.7%	71.4%	59.5%	91.3%	77.9%
No	n	17	8	7	14	34	4	84
	%	23.6%	11.1%	12.3%	28.6%	40.5%	8.7%	22.1%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Chi-square	Value=30.802, df=10, p=.000							

Source: Questionnaire Survey, June-October, 2016

5.4.3.7 Loosing Valuable Natural Resources

Due to sea level rise we will lose our environmentally and economically valuable forest resources. Forest maintains the ecological balance and also a rich source of firewood, lumber, paper, foodstuff, and raw materials of different industry. According to the prediction of WB 2000 by 2100 whole Sundarbans will be lost due to sea level rise. Here it is noted that the Sundarbans is a major earning source of 10 million subsistence people.[40] People those who rely on Sundarbans and other coastal forests will be vulnerable simultaneously the country will also loose forest products. On the other hand to meet the local demand we have to import forest product from abroad by the cost of foreign reserve. So, both in the short run and long run the socio-economic cost of losing natural resources will be higher due to SLR.

5.4.3.8 Reduction of Social Welfare

Sea level rise will cause to disrupt the social welfare of the people of coastal area. Poor people will be more vulnerable and social safety net will be broken down of the affected areas. About 40% of the respondents think high possibility of reducing social welfare due to sea level rise, 37.1% think moderate possibility and 26.1% think low possibility. Social welfare practice is normally found in comparatively people of higher level of living standard, hence it is seen Nilgonj and Khurushkul are in better position as per the statement of the respondents which are also in better position in terms of living standard.

[40] M. S. Islam, "Perspectives of the Coastal and Marine Fisheries of the Bay of Bengal, Bangladesh," *Ocean & Coastal Management 46,* no. 8 (2003). 766.

Table 5.32: Reduction of Social Welfare Due to Sea Level Rise

Reduction of Social Welfare		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Low possibility	n	10	17	18	11	21	12	89
	%	13.9%	23.6%	31.6%	22.4%	25.0%	26.1%	23.4%
Medium Possibility	n	46	34	19	11	13	18	141
	%	63.9%	47.2%	33.3%	22.4%	15.5%	39.1%	37.1%
High Possibility	n	16	21	20	27	50	16	150
	%	22.2%	29.2%	35.1%	55.1%	59.5%	34.8%	39.5%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Chi-square	Value=30.802, df=10, p=.000							

Source: Questionnaire Survey, June-October, 2016

5.5 Statistical Assessment of SLR Impact

Sea level rise of different scenarios in future has different impact on the livelihood security of coastal people. In the present study it was tried to find out the impact from different directions. Different impact finally creates the financial loss which makes the coastal people worry to face. A strong correlation has been fund among them.

Table 5.33: Correlation Matrix of Financial Losses among Different Variables

		Total Financial Loss of Household	Loss of Agriculture	Loss of Fisheries	Damage of Settlement	Increasing Diseases	Increasing Inundation
Total Financial Loss of Household	Pearson Correlation	1	.176**	.122*	.220**	.153**	.178**
	Sig. (2-tailed)		.001	.026	.000	.005	.001
	N	380	380	380	380	380	380
Loss of Agriculture	Pearson Correlation	.176**	1	.288**	.438**	.552**	.583**
	Sig. (2-tailed)	.001		.000	.000	.000	.000
	N	380	380	380	380	380	380
Loss of Fisheries	Pearson Correlation	.122*	.288**	1	.219**	.235**	.240**
	Sig. (2-tailed)	.026	.000		.000	.000	.000
	N	380	380	380	380	380	380
Damage of Settlement	Pearson Correlation	.220**	.438**	.219**	1	.458**	.680**
	Sig. (2-tailed)	.000	.000	.000		.000	.000
	N	380	380	380	380	380	380
Increasing Diseases	Pearson Correlation	.153**	.552**	.235**	.458**	1	.603**
	Sig. (2-tailed)	.005	.000	.000	.000		.000
	N	380	380	380	380	380	380
Increasing Inundation	Pearson Correlation	.178**	.583**	.240**	.680**	.603**	1
	Sig. (2-tailed)	.001	.000	.000	.000	.000	
	N	380	380	380	380	380	380

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

It is evident that different future SLR impact will create havoc to the livelihood security of the people of coastal zone. During field study it was found that the respondent agreed some major impact to happen. In correlation among the variables it was found that Variables of impacts are correlated.

Table 5.34: Correlation among Different Variables of Impact

		Soil Fertility	Salinity Intrusion	Inundation	Riverbank Erosion	Water Logging
Soil Fertility	Pearson Correlation	1	.443**	.586**	.492**	.641**
	Sig. (2-tailed)		.000	.000	.000	.000
	N	380	380	380	380	380
Salinity Intrusion	Pearson Correlation	.443**	1	.795**	.561**	.873**
	Sig. (2-tailed)	.000		.000	.000	.000
	N	380	380	380	380	380
Inundation	Pearson Correlation	.586**	.795**	1	.884**	.906**
	Sig. (2-tailed)	.000	.000		.000	.000
	N	380	380	380	380	380
Riverbank Erosion	Pearson Correlation	.492**	.561**	.884**	1	.783**
	Sig. (2-tailed)	.000	.000	.000		.000
	N	380	380	380	380	380
Water Logging	Pearson Correlation	.641**	.873**	.906**	.783**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	380	380	380	380	380

**. Correlation is significant at the 0.01 level (2-tailed).

5.6 SLR Impact on Macro-economic Loss in the Study Area: Regression Result

Based on the correlation coefficient result total eleven variables are included in the linear regression model. It reveals that model for study area having 55.31% of total variance ($p<0.01$). Five variables are found significant influence on future macro-economic loss such as Agricultural impact, Fishery Sector impact, Inundation Related impact, Erosion Related Impact, Tourism Sector Impact, Educational impact, Ecological impact and Health impact.

Impact of agricultural appears as a significant predictor for future adversity of SLR that explains 22.6% ($p<0.01$) of total variance. A significant portion of people in the study area are dependent on agriculture. Future adversity by sea level rise will seriously impact and disrupt the livelihood option of poor agriculture dependent communities in the coastal zone of Bangladesh. Impact of fishery sector appears as a significant predictor for future effect of SLR that explains 12.9% ($p<0.01$) of total variance. Fishery of coastal area of Bangladesh is important livelihood option and main source of protein which will be impacted by SLR. Regression result is consistent about the scenario.

Inundation impact appears as a significant predictor for future impact of SLR that explains 31.2% ($p<0.01$) of total variance. Inundation affects the production, communication, settlement etc. Inundation by SLR will disrupt the livelihood option of coastal inhabitants. Erosional impact appears as a significant predictor for future impact of SLR that explains 18.6% ($p<0.01$) of total variance. SLR will increase erosion which has tremendous impact on environment; finally it will threaten the livelihood security.

Tourism impact appears as a significant predictor for future impact of SLR that explains 18.3% ($p<0.05$) of total variance. A significant portion of coastal people depend on tourism for livelihood option. But tourism sector is highly vulnerable to future adversity of SLR. Regression result is al so consistent in line with the potential impact of SLR regarding tourism. Likewise education loss, ecological loss and employment loss explain 12.6% ($p<.05$), 13.7% ($p<.05$), 22.6% ($p<.05$) and 21.1% ($p<.05$) as significant predictors.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.785[a]	.616	.610	308.41460

a. Predictors: (Constant), Agricultural Loss, Fishery Sector Loss, Inundation Related Loss, Erosion Related Loss, Tourism Sector Loss, Education Loss, Basic Need Loss, Salt Industry Loss, Ecological Loss, Employment Loss, Medical Expense.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	49609597.567	11	9921919.513	54.310	.000[b]
	Residual	30913858.255	369	95119.564		
	Total	80523455.822	380			

a. Dependent Variable: Macro-economic Loss

b. Predictors: (Constant), Agricultural Loss, Fishery Sector Loss, Inundation Related Loss, Erosion Related Loss, Tourism Sector Loss, Education Loss, Basic Need Loss, Salt Industry Loss, Ecological Loss, Employment Loss, Medical Expense.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1111.820	110.413		10.070	.000
	Agricultural Loss	766.518	153.240	.226	5.002	.000
	Fishery Sector Loss	726.282	204.221	.129	3.556	.000
	Inundation Related Loss	1170.419	177.213	.312	6.605	.000
	Erosion Related Loss	585.775	143.504	.186	4.082	.000
	Tourism Sector Loss	682.198	204.765	.183	3.332	.001
	Education Loss	489.11	126.12	.126	4.526	.004
	Basic Need Loss	377.14	211.18	.135	3.397	.576
	Salt Industry Loss	511.21	189.21	.125	5.329	.694
	Ecological Loss	672.17	161.19	.137	3.425	.003
	Employment Loss	381.15	171.26	.226	5.121	.027
	Medical Expense	327.29	151.23	.211	3.327	.002

a. Dependent Variable: Macro-economic Loss

b. Predictors: (Constant), Agricultural Loss, Fishery Sector Loss, Inundation Related Loss, Erosion Related Loss, Tourism Sector Loss, Education Loss, Basic Need Loss, Salt Industry Loss, Ecological Loss, Employment Loss, Medical Expense

5.7 Chapter Summary

The coastal zone of Bangladesh is globally recognized as an extremely vulnerable area. Impacts of climate change and sea-level rise should have real consequences on the livelihoods of the coastal people as it would be affected by salinity intrusion, flooding, drainage congestion, cyclones, heavy storms and erosion of the land masses. Therefore, agriculture in low-lying areas is likely to become increasingly difficult to sustain. The land mass of Bangladesh being already quite limited and its population density one of the highest in the world, continuous land engulfing by rising sea water will only bring grave consequences forcing the coastal people to become climatic refugees. These climatic refugees will exert immense pressure on the already existing vulnerable food securities. Therefore, collection of relevant information relating to the degree of global warming on sea-level rising and its consequences on the coastal land masses and population are essential in formulating policies for food security in the coastal regions of Bangladesh. The global warming and sea-level rising are geographically inequitable with real consequences on livelihood security for the coastal people of Bangladesh. The present chapter investigates the following consequences of SLR on livelihoods which may make the coastal people more vulnerable to cope with the upcoming situation.

1) In the present study it is identified that the livelihood vulnerability of the natural resource-dependent coastal community that may arise due to SLR and its associated events. Climate change induced Sea level rise problem in the study area has awful effect upon the life of the inhabitants.

2) Based on perception analysis from a list of sources of livelihood insecurity major dimensions of insecurity are identified. These are a) infrastructure damage, b) food and nutritional security, c) low earning and higher maintenance cost, d) loss of employment in offshore activities, and e) crisis of potable water and public health risk.

3) In the coastal districts of Bangladesh the food production is already vulnerable due to the cyclonic storm, tidal surges, salinity intrusion and impeded drainage. The global warming and associated sea level rising will further aggravate this situation. Several earlier studies and perception of local inhabitants agreed about matter.

4) It is revealed from all projections that a 1-2^{0}C global warming will lead to about 14, 32 and 88 cm sea-level rise in 2030, 2050 and 2100 respectively which may inundate about 8, 10 and 16% of total land of Bangladesh. Therefore, agriculture in low-lying areas is likely to become increasingly difficult to sustain.

5) Most of the exposed coastal parts and associated islands of Satkhira, Patuakhali and Cox's Bazar Districts lie within 1m from sea level where invasion of saline water is common. It is predicated that these areas will be inundated and unsuitable for crop production due to sea-level rise in the next 50 years.

6) It is observed in the study that the predominant crop in coastal belt is Aman rice. In Boro season, Aus, some pulses, vegetables, groundnut etc. are cultivated with Aman rice and there remains the rest period unused due to salinity which will be more critical due to sea level rise.

7) The study reveals that crop cultivation is seriously hampered in dry season due to presence of salinity either in surface water or in soil. Salinity intrusion by sea level rise will create the situation more acute for agriculture.

8) It is found in the study that many plants and animals rely on wetlands, beaches, and other coastal habitat which are threatened by sea-level rise. Habitat losses could lead fish and birds to move to other places.

9) It is found in the study that sea level rise will not create only physical vulnerability simultaneously it will exaggerate socio-economic vulnerability like education, social interaction, security, tourism, poverty etc.

10) SLR impacts are more acute and hazardous such as the change of occupation, migration decision of household, food insecurity etc. Undoubtedly, the most vulnerable people like marginal farmers, fishermen and poor women will suffer most in coastal zone of Bangladesh by sea level rise consequences.

Chapter Six
Households Assets Portfolio and Livelihood Strategies

6.1 Introduction

Every household habitually owns a set of assets or capitals, but access and control over such assets varies among different households. Disparity of entitlement, access and control over resources provide households different levels of base to make choices, which eventually result into actual activities for earning means of living.[1] These activities help household to generate income, which is used up in a ranges of ways to get sustainability in daily life. Engage in production and exchanges of social classes or livelihood groups depend on these everyday activities. A household may enhance its assets base by undertaking certain strategies or choices, though such changing in assets is a dynamic process and having multiple vulnerabilities from different stressors. It usually copes with crisis by mobilizing assets and if lack of resilience or capacity persists become more vulnerable to future threats. In essence, a livelihood study put emphasize to characterize major livelihood groups considering ownerships, access to and control over the livelihood capitals/assets, and strategic choices to use such assets/capitals for income earning and facing the vulnerabilities from multiple stressors. In present study an attempt has been made to document the major livelihood groups, their asset portfolios, vulnerabilities and livelihood strategies considering the unique character of coastal zone in compare to the rest of the country.

6.2 Livelihood Assets and Strategies

Resources available at household level in terms of ownerships, access to and control over resources are the main conditions to define livelihood. In the present study, livelihood capitals/assets of selected six unions are examined based on the concept of livelihood asset pentagon of Department for International Development (DFID), which encompasses five types of core assets i.e. human, natural, physical, financial and social.[2] In coastal region of Bangladesh access to these assets are likely to have varied according to the influence on individual's responses and coping strategies against the natural disasters.

---

[1] Carole Rakodi, "A Capital Assets Framework for Analyzing Household Livelihood Strategies: Implications for Policy," *Development Policy Review* 17, no. 3 (1999): 315.

[2] DFID. Sustainable Livelihood Frame Work, 2000 available at https://opendocs.ids.ac.uk/ opendocs/handle/123456789/ 3390id livelihood framework accessed 12 November 2016.

Human assets are skills, knowledge, working ability and good physical health that enable people to carry out livelihood strategies to achieve livelihood outcomes.[3] Human assets included in this study are knowledge, skill, experience, leadership potential and ability to work, considering that combination of such indicators might have influence on responding against disasters or adoption of coping strategies to achieve livelihood security. Likewise, natural assets includes access to open source resources, soil fertility status, irrigation facility, salinity and tidal surge events etc. are considered having differential impacts on coastal livelihoods. Financial assets are most versatile among five types of assets; which can be transformed in to any other types of assets for achieving livelihood security outcomes.[4] In the present study financial assets include stock of money, bank savings, NGO savings, group deposit, and liquid assets such as livestock, poultry, jewelry etc. Physical assets include the infrastructures such as access to road networks and means of transportation, access to machineries and accessories for farming or fishing. Without having ownership of such machineries or accessories farmer or fishers need to depend on haired materials, which often delay their activity due to unavailability of these materials, inability to hire or other constrains. Social capital includes norms, values and attitudes that influence people to work together, for example reciprocity and solidarity. Such ability develops through connection, networking and trust building that enable people to work together with expanding access to wider institutions. In present study social capital is measured through access to mass media, individual connection, participation in different activities, and membership status in various organizations.

6.3 Assessing Livelihood Capitals

According to DFID livelihood framework an analytical model is developed by identifying the necessary indicators of five livelihood assets/capitals. These indicators are determined considering the coastal livelihoods. Livelihood capitals are different and identified indicators are not homogenous in terms of types and measurement methods. In this study various scaling and indexing procedure have been applied to make the indicators comparable to ensure meaningful explanations.

---

[3] DFID. *Sustainable Livelihoods Guidance Sheets, The Livelihoods Framework*. Department for International Development, UK. Section 2(1999) available at www.eldis.org/vfile/upload/1/document/0901/section2.pdf *(accessed on 13 March 2016).*

[4] Ibid., *(accessed on 13 March 2016).*

Human Capital

According to the economists and policy makers measuring human capital are debated term as the indicators are not specific as they are closely related with each other. For example, average year of education or enrollment rate is used measuring human capital.

Likewise, some other proxies are also used for indirectly measuring human capital such as skill, knowledge and leadership potential. Measuring skill and knowledge, level of education, experience gained from training programs, and ability to solve own problems and work in adverse conditions can be used as proxies. Similarly, leadership capability can be measured through individual's frequency of participation in different group meetings together with motivational capacity or facilitating capacity in the community. Likewise, individual's health condition is a potential indicator to measure human capital, as good health indicates higher ability to work.[5]

A five point Likert scale was used to measure skill and knowledge, and leadership potentials considering the discrete values of 0.00, 0.25, 0.50, 0.75 and 1. Scaling process and criteria of measuring human capital is presented in table 6.1. To prepare the human capital index (HCI) average rating of all indicators has been calculated by using the following formula:

Human capital Index (HCI) = $(\sum HCI_1/N+\sum HCI_2/N\ldots\ldots\sum HCI_{11}/N)/11$

Where, HCI = Human Capital Index

HCI_1, HCI_2….. = Human Capital Indicators

N = Total sampled respondents

On the whole human capital index (HCI) is calculated by adding the average value of all indicators and dividing the total by 11 to get the overall average of human capital index value. However, average of all human capital indicators provides the human capital index of each village. Higher index value represents higher level of human capital having greater level of ability to face the adversity posed by disaster more efficiently and higher ability to secure livelihood.

[5] Angela Baron, "Measuring human capital," *Strategic HR Review* 10, no. 2 (2011): 30.

Table 6.1: Indicators and Measuring Scale of Human Capital

Indicators	Measuring Scale				
	0.00	0.25	0.50	0.75	1
1.Education level (HCI_1)	Illiterate	Can read and write	Primary school	Secondary School	Higher Education
2. Ability to work in adverse condition (HCI_2)	None	Low	Moderate	High	Very high
3. Having disaster related training (HCI_3)	No	1 time	2 times	3 times	More than 3times
4.Level of experience gained from training (HCI_4)	None	Low	Moderate	High	Very high
5. Solving own problems (HCI_5)	Never	Often	Very often	Usually	Always
6. Representative of group (HCI_6)	Never	1 times	2 times	3 times	More than 3 times
7. Exposing idea in group meeting (HCI_7) Exposing idea in group meeting (HCI_7)	Never	Often	Very often	Usually	Always
8. Helping other to solve problem(HCI_8) Helping other to solve problem(HCI_8)	Never	Often	Very often	Usually	Always
9. Motivating others for community activities (HCI_9)	Never	Often	Very often	Usually	Always
10. Facilitating community and GO- NGO initiatives (HCI_{10})	Never	Often	Very often	Usually	Always
11. Solving conflict within the community (HCI_{11})	Never	Often	Very often	Usually	Always

Natural Capital

A significant amount of the coastal rural livelihoods depend on natural resource. Coastal people's livelihood options depend on availability of both natural and social resources that they possess or have access. Natural capitals are the set of natural factors that include the stock of natural resources. One receives resources for livelihoods such as land, water and common source environmental resources and environmental services as natural capital. In present study few indicators are selected to measure natural capital based on individual respondent's perception about the access to natural resources.

The indicators are access to common pool resources such as open water, forest, grazing land and khas land or char land. Soil is an important natural capital in coastal zone which is more specific for agro-based households. Hence, individual's perception about soil fertility status of agricultural land and its trends over past 10 years is also considered. Likewise, irrigation facility and frequency of tidal surge events also considered as these have influence on agricultural production. A five point Likert scale was used to measure the perception about individual natural capital indicator with discrete values of 0, 0.25, 0.50, 0.75 and 1. Scaling procedure and criteria of measuring natural capital is presented in below (table 6.2).

Natural capital index (NCI) is calculated by summing up the average rating of all indicators by using the following formula:

Natural capital Index (NCI) = $(\sum NCI_1/N + \sum NCI_2/N \ldots\ldots \sum NCI_9/N)/9$

Where, NCI = Natural Capital Index

NCI_1, NCI_2…..= Natural Capital Indicators

N = Total sampled Respondents

Table 6.2: Indicators and Measuring Scale of Natural Capital

	Measuring Scale				
Indicators	0	0.25	0.50	0.75	1
1. Access to open water bodies (NCI_1)	None	Low	Moderate	High	Very high
2. Access to forests (NCI_2) Access to forests (NCI_2)	None	Low	Moderate	High	Very high
3. Access to grazing lands (NCI_3)	None	Low	Moderate	High	Very high
4. Access to khas land or char land (NCI_4)	None	Low	Moderate	High	Very high
5. Soil fertility status (NCI_5) Soil fertility status (NCI_5)	Do not know	Low	Moderate	High	Very high
6. Trend of soil fertility change in past ten years (NCI_6)	Rapidly decreased	Decreased	No change	Increased	Rapidly increased
7. Rating of water sufficiency for irrigation (NCI_7)	Highly insufficient	Insufficient	Moderately sufficient	Sufficient	Highly sufficient
8. Rating of soil salinity (NCI_8) Rating of soil salinity (NCI_8)	None	Low	Moderate	High	Very high
9. Frequency of tidal surge events (NCI_9)	Never	Rare	Sometimes	Often	Always

The overall natural capital index (NCI) is calculated by adding the average of all natural capital indicators and dividing the total by 9 to get the overall natural capital index value. Higher index value represents higher level of natural capital means greater level of access to natural resources, which leads to higher ability to face the adversity posed by disaster more efficiently to secure livelihoods.

Financial Capital

Financial capital is any economic resource. It refers to the basic productive assets such as cash, savings, credit, remittances, pension and other economic and productive assets which provide different livelihood options. In present study, financial capital is calculated based on available financial deposit and monetary values of liquid assets of each households such as reserve of money in the form of cash, deposits in banks, cooperatives and groups, remittance and pension, and liquid assets from livestock, poultry, jewelry, furniture, storage of food and cash crops, trees and other assets which can provide liquid money.[6] After converting all form of such assets to monetary value for each household, is then divided by the aggregate highest available financial deposit and monetary value among the study villages to get financial capital index. Following formula is used to calculate financial capital index.

$FCI = Av/Av_h$

FCI = Financial Capital Index

Av = Available financial deposit and monetary value of liquid assets of each households

Av_h = Highest available financial deposit and monetary value among the study villages

Physical Capital

Physical capital is tangible capital that is created by humans and somehow used in production. It includes the basic infrastructure such as means of transportation and communication, shelter, production apparatus and means which help people to pursue their livelihoods. In present study number of indicator are used to measure physical capital. For instances quality of road to reach in market, accessibility to road, access to cyclone shelters, access to agricultural and fishing accessories such as tractor, harvester, boat, net, and means of transportation such as rickshaw, van, motorbike, and bicycle. Selection of such indicators is important in various reasons, for example quality of road network and means of transportation are important indicators of people's mobility, as coastal areas are always lack of good communication network. Such poor communication badly impacted coastal people's livelihood in many ways such as marketing of

[6] Arnold C. Cooper, F. Javier Gimeno-Gascon and Carolyn Y. Woo, "Initial human and financial capital as predictors of new venture performance," *Journal of business venturing* 9, no. 5 (1994): 371.

agricultural and dairy products, fishes and reaching in the cyclone shelters and so on. Likewise, access to agricultural and fishing accessories is important physical assets. Farmer who has their own machinery are in better position in terms of access to such assets in compare to the farmer do not own machinery. Due to the lack of resources poor farmer are always dependent on haired or borrowed machinery. It is equally true for the fishermen. Five point Likert scale with the value of 0.0, 0.25, 0.5, 0.75 and 1 have been used in to measure physical capital. Indicators used in this regard are presented in below table 6.3. Overall physical capital index is the average of all indicators, and higher index values represent better physical asset position.

Table 6.3: Indicators and Measuring Scale of Physical Capital

Indicators		Measuring Scale				
		0	0.25	0.50	0.75	1
1.	Access to road network	Very poor	Poor	Moderate	Good	Very good
2.	Access to cyclone shelters	Very poor	Poor	Moderate	Good	Very good
3.	Access to tractor	Very poor	Poor	Moderate	Good	Very good
4.	Access to harvester	Very poor	Poor	Moderate	Good	Very good
5.	Access to boat	Very poor	Poor	Moderate	Good	Very good
6.	Access to nets	Very poor	Poor	Moderate	Good	Very good
7.	Access to rickshaw/van	Very poor	Poor	Moderate	Good	Very good
8.	Access to motor bike	Very poor	Poor	Moderate	Good	Very good
9.	Access bicycle	Very poor	Poor	Moderate	Good	Very good

To prepare the physical capital index (PCI) average rating of all indicators has been calculated by using the following formula:

Physical capital Index (PCI) = $(\sum PCI_1/N+\sum PCI_2/N\ldots\ldots\sum PCI_9/N)/9$

Where, PCI = Physical Capital Index

PCI_1, PCI_2….. = Physical Capital Indicators

N = Total sampled respondents

Social Capital

Measuring social capital is not possible by single entity rather it is multi-dimensional which includes access to information, networks, organizational memberships, relationships of trust and reciprocity and access to wider institution of society which enable people to pursue livelihoods.[7] Like measuring of human capital it has no direct way to measure social capital. Taking some strategies it is possible to measure social capital. Education level or years of education is a widely accepted indicator of measuring human capital.

Even now no such well accepted proxies are found rather research for better proxies are still ongoing. Therefore, social capital is not yet measured in any well acceptable way rather has been deal with different ad-hoc ways with contextually relevant indicators based on individual research needs. In this regard, present study categorized social capital indicators in four broad groups which cover almost all the aspects of social capital such as access to mass communication, access to individual communication, participation and connection, memberships in the groups.

Access to mass communication indicates level of access to information (either disaster related or others) received from various sources such as radio, television, newspaper and other printed materials such as leaflets. Likewise, individual communication includes individuals access to disaster mitigation volunteers, agricultural extension workers, fishery department workers, health and family planning workers, union parishad, community based organizations or non-government organizations. Access to information through mass media or individual communication with representatives from different organizations are measured in five point Likert scale such as no access, less than once in a month, once in a month, 2-3 days in a month, and more than 3 days in a month having the scores of 0, 0.25, 0.50, 0.75 and 1 (table 6.4).

[7] D. Carney, Implementing the Sustainable Rural Livelihoods Approach. In: *Sustainable Rural Livelihoods – What Contribution Can We Make?* Carney, D. (ed.) (London: Department for International Development, 1998), 3.

Table 6.4: Indicators and Measuring Scale of Access to Mass Communication and Individual Communication

Indicators (Access to Climate Change related disaster or other information)	Measuring Scale				
	0	0.25	0.50	0.75	1
Mass communication					
1. Radio ($MICI_1$)	no access	<once in a month	once in a month	2-3 days in a month	>3 days in a month
2. Television ($MICI_2$)	no access	<once in a month	once in a month	2-3 days in a month	> 3 days in a month
3. Mobile phone ($MICI_3$)	no access	< once in a month	once in a month	2-3 days in a month	> 3 days in a month
4. Newspaper ($MICI_4$)	no access	< once in a month	month once in a	month 2-3 days in a	> 3 days in a month
5. Printed materials (leaflets) ($MICI_5$)	no access	<once in a month	once in a month	2-3 days in a month	> 3 days in a month
Individual Communication					
6. Disaster mitigation workers ($MICI_6$)	no access	< once in a month	once in a month	2-3 days in a month	>3 days in a month
7. Agriculture extension workers ($MICI_7$)	no access	< once in a month	once in a month	2-3 days in a month	> 3 days in a month
8. Fishery department workers ($MICI_8$)	no access	< once in a month	once in a month	2-3 days in a month	> 3 days in a month
10. Health and Family planning workers ($MICI_9$)	no access	< once in a month	once in a month	2-3 days in a month	> 3 days in a month
11. Union Parishad ($MICI_{10}$)	no access	< once in a month	once in a month	2-3 days in a month	> 3 days in a month
12. NGOs and CBOs ($MICI_{11}$)	no access	< once in a month	once in a month	2-3 days in a month	> 3 days in a month

$$MICI = (\sum MICI_1/N + \sum MICI_2/N \ldots\ldots \sum MICI_{11}/N)/11$$

Where, MICI = Mass Communication and Individual Communication Index

$MICI_1$, $MICI_2 \ldots . MICI_n$ = Mass Communication and Individual Communication Indicators

N = Total sampled Respondents

Participation and connection indicates sharing knowledge among community members and with other government and non-government organizations. To measure the variable participation and connection, several indicators such as participation in the community awareness campaign for disaster risk reduction, frequency of participation in the community based disaster mitigation or other relevant activities, communication with NGOs and other voluntary organization work for disaster mitigation, status of relationship with others in the community and assisting others during adversities. However, to measure through such indicators five point Likert scale is used with the score values of 0, 0.25, 0.50, 0.75 and 1 (table 6.5).

Table 6.5: Indicators and Measuring Scale of Participation and Connection

Indicators	Measuring Scale				
	0	0.25	0.50	0.75	1
1. Participation on community based awareness campaign ($PACI_1$)	Never	Rarely	Sometime	Often	Always
2. Participation in disaster mitigation activities ($PACI_2$)	Never	Rarely	Sometime	Often	Always
3. Connection with NGOs for disaster mitigation ($PACI_3$)	None	Rarely	Sometime	Often	Always
4. Relationship with others in the community ($PACI_4$)	No relation	In some extent	Moderate	Good	Very good
5. Assisting others in the community during crisis ($PACI_5$)	Never	Rarely	Sometimes	Often	Always

$PACI = (\sum PACI_1/N+\sum PACI_2/N\ldots\ldots\sum PACI_5/N)/5$

Where, PACI = Participation and Connection Index

$PACI_1$, $PACI_2$….$PACI_n$ = Participation and Connection Indicators

N = Total sampled Respondents

Membership status in the groups in many instances indicates social status of respondents. In study unions various groups were identified such as voluntary group, religious group, micro-credit group, cooperative group. Membership status of respondents in different groups varies according to the social status. Another indicator for example relationship with union parishad is used in this study to understand membership status of individual. Such indicator could be more relevant to termed as political capital indicator. However, in present study this indicator is used under social capital indicator. Five point scale indicating no membership, member but low participation, member with moderate participation, member with high participation, member in the core committee with the score values of 0, 0.25, 0.50, 0.75 and 1 is used to measure membership status in the groups (table 6.6). Finally, overall social capital index (SCI) is calculated based on the average of access to mass communication and individual communication, participation and connection, and membership status in groups. Higher index value of social capital indicates comparatively better position of withstand against disaster to secure livelihoods.

$MGI = (\sum MGI_1/N+\sum MGI_2/N\ldots\ldots\sum MGI_5/N)/5$

Where, MGI = Membership in Groups Index

MGI_1, MGI_2….MGI_n = Memberships in Groups Indicators

N = Total sampled Respondent

Table 6.6: Indicators and Measuring Scale of Membership Status in Groups

Indicators	Measuring Scale				
(Membership status)	0	0.25	0.50	0.75	1
1. Voluntary group (MGI_1)	No membership	Member with low participation	Member with moderate participation	Member with high participation	Member of core committee
2. Religious group (MGI_2)	No membership	Member with low participation	Member with moderate participation	Member with high participation	Member of core committee
3. Micro-credit group (MGI_3)	No membership	Member with low participation	Member with moderate participation	Member with high participation	Member of core committee
4. Cooperative groups (MGI_4)	No membership	Member with low participation	Member with moderate participation	Member with high participation	Member of core committee
5. Union Parishad (MGI_5)	No membership	Member with low participation	Member with moderate participation	Member with high participation	Member of core committee

6.4 Livelihood Capitals and Asset Pentagon

Based on the above mentioned procedure calculated livelihood capital indices are presented in below table 6.7. It reveals that overall human capital index is higher in Nilgonj Union with a value of 0.44 out of 1 followed by Munshigonj (0.41), Gabura (0.38), Baruakhali (0.37), Khurushkul (0.34) and Lalua (0.29). Significant difference exists among the villages in terms of human capital. Respondents of Munshigonj have better accomplishment of human capital than other five. In contrast, Gabura Union (0.45) has higher natural capital than other five unions. However, it is due to the higher access of villagers of Island (Gabura) to open access common pool natural resources such as sea, river, grazing lands and khas lands. Higher access to such resources had attracted many migrants to settle in this village, though this is most vulnerable location sea level rise among five unions. Similarly, Lalua union also enjoys more natural capital than Inland unions. As Lalua union is located in the seashore of the Bay of Bengal, hence villagers have higher access to deep sea fishing. Inland union is agro-based and limited common source resources are available. Therefore, natural capital index reveals comparatively lower value.

Financial capital indices do not reveal significant difference among unions. It reveals that financial capital index value is comparatively higher in Munshigonj (0.19) than

Khurushkul (.11), Nilgonj (.10), Lalua (.08) and Bharuakhali (.08). Among the villages sea attached accounted for lower financial capital which reveals in general poor economic condition of respondents.

Physical capital index reveals that higher value is accounted for Munshigonj and Khurushkul (0.31) than Gabura (0.29) Lalua (0.29), Bharuakhali (.28) and Nilgonj (.27). Higher physical capital index score in Munshigonj reveals that respondents had higher access and ownership of physical assets such as fishing and agricultural accessories. Fishermen in attached sea side usually catch fish in deep sea thus require huge amount of investment for mechanized boats and nets.

On the other hand, large number of respondents in nearer to coastline are also fishermen, but usually unable to invest more money for boat and nets due to poor economic condition. Agricultural accessories are not as expensive as fishing accessories; and number of farmer is higher than fisher, and fishermen are engaged in subsistence level fishing, hence interior unions shows less physical capital index value. Social capital indices show better situation in Munshigonj (0.29) and Nilgonj (.29) followed by Lalua (0.28), Gabura (.24), Khurushkul (.24) and Bharuakhali (0.23) village. Higher performance of social capital index values in Inland village reveals better social coherence among the inland coastal communities.

On the other hand, majority of the respondents in nearer to coast line are the immigrants from different inland locations, therefore social bonding is not as tight as interior locations. Likewise, institutional activities are also comparatively less in the coastline due to the poor transportation and remote location. On the other hand, due to the closeness to the nearby thana headquarters respondents in interior area enjoy more services from government and non-government organizations.

Similarly, access to livelihood assets significantly varies among three livelihood groups (table 6.7). Accesses to livelihood capitals are significantly higher for farmer and fisher than wage laborer. This reveals relatively weaker asset portfolio of wage laborer than farmer and fisher. Between farmer and fisher human and social capital index value is higher for farmer, while natural and physical capital index value is higher for fishermen. This indicates relatively better situation of farmer than fishermen. Higher human capital unveils better physical ability, skill and knowledge of farmer than fisher. Similarly, having higher financial capital reveals higher ability of converting liquid assets and savings to gain other capitals. Higher social capital reveals relatively better participation and connection with various community groups and activities of farmer groups. On the other hand, higher natural capital for fishermen reveals higher access of fishing communities to common pool resources such as sea and rivers. Fishing accessories require higher investment than agriculture accessories. Therefore, physical capital for fisher groups is higher than farmer.

Table 6.7: Livelihood Assets Index by Village and Livelihood Groups

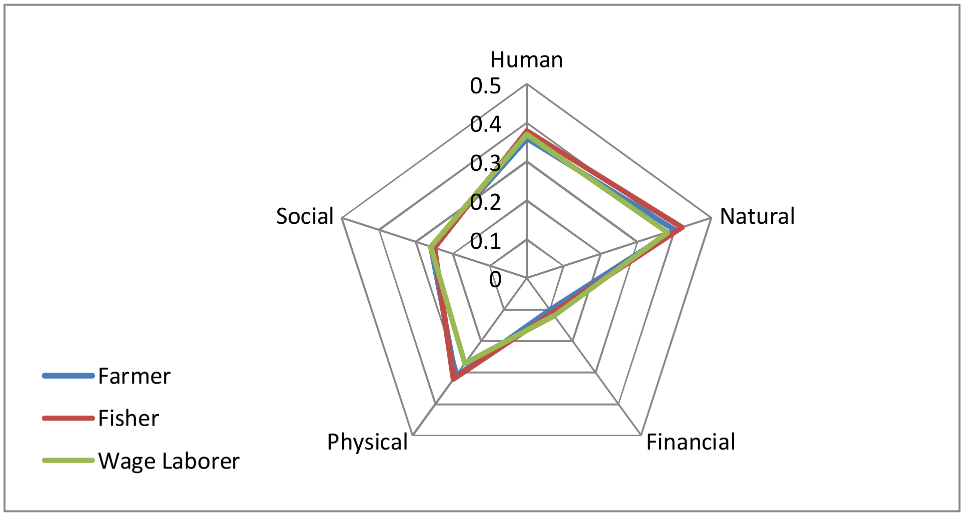
Livelihood Capitals	Study Unions							
	Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	ANOVA	Sig.
Human	.41	.38	.29	.44	.34	.37	F= 10.87**	.000
Natural	.42	.45	.40	.35	.37	.38	F= 37.64**	.000
Financial	.19	.09	.08	.10	.11	.08	F= 3.255	.237
Physical	.31	.29	.29	.27	.31	.28	F= 44.71**	.000
Social	.29	.24	.28	.29	.24	.23	F= 17.69**	.000
Livelihood Capitals	Livelihood Groups							
	Farmer	Fisher	Wage Laborer				ANOVA	Sig.
Human	.36	.38	.37				F= 11.103**	.000
Natural	.40	.42	.38				F= 12.153**	.000
Financial	.10	.11	.12				F= 10.615*	.025
Physical	.31	.32	.27				F=41.106**	.000
Social	.26	.25	.26				F=8.358**	.000

* $p < 0.05$, ** $p < 0.01$

Source: Questionnaire Survey, June-October, 2016

Radar diagram is plotted based on the calculated scores of five livelihood capital indices to present in livelihood asset pentagon (figure 6.1). The shape of pentagon represents the variations in villagers' and livelihood groups' access to five livelihood capitals. The center point of the pentagon represents the zero value in terms of access to assets. While, deviations from the center point of pentagon to the outer sides represents higher values of livelihood capitals. Figure 6.1 presents the livelihood asset pentagon to depict the overall access to five livelihood capitals by groups in six locations.

Figure 6.1: Livelihood Asset Pentagon by Livelihood Groups



6.5 Major Livelihood Groups and Strategies

Socio-economic classes of the society are generally identified by some indicators. In rural Bangladesh land is considered as one of the vital factors together with other factor to determine socio- economic classes. People's occupations coupled with associations of production often portray livelihood groups as well. For instance fishers, day laborers or wage laborers are classified as distinct social class with low status; whereas small farmer and large land owners is elite rural people with an image of patron.[8]

Agricultural laborers are the largest livelihood group in terms of number in rural Bangladesh. Generally one in every three households is depended on agriculture. Small farmers are the transitional groups between landless and large landowners though they are very close to landless. Fishermen are the single largest groups among the non-agricultural occupation. However, livelihoods in the coastal Bangladesh are broadly clustered into two groups such as natural resource based (agriculture, fishing, aquaculture, extraction of forest resources) and human resource based (boat building, net making, fish processing, trading). There are over seven million households are in coastal zone, out of which agricultural laborer, small farmer, fisher and urban poor covers 71% of total households (table 6.8).

[8] PDO-CZMP, *Where Land Meets The Sea: A Profile of the Coastal Zone Of Bangladesh* (Dhaka: The University Press Limited, 2004a), 317.

Table 6.8: Distribution of Major Livelihood Groups in Coastal Bangladesh

Livelihood Groups in the Coastal Zone	Number of Households in 2011	
	Number in million (estimated)	Percentage
Agriculture labor	1.81	26.4
Small Farmer	1.79	26.1
Fisher	0.53	7.8
Urban Poor	0.70	10.2
Total (4 groups)	4.84	70.5
Total Coastal Zone	6.86	100.0

Source: BBS, 2011.[9]

In present study based on field survey, observation and focus group discussions major livelihood groups are identified as farmer, fisher and wage laborer (table 6.9). Farmer includes small, medium and large farmers. This study finds that in study villages majority of farmers belongs to small farmer category. Likewise, fisher group includes fishermen who usually catch fish in rivers, cannels and sea. Fish fry collectors are also included in fisher category. Wage laborer group includes both agricultural and non-agricultural labors including house helpers or maidservants. Profile of these livelihood groups in the study villages are presented below (table 6.9).

Table 6.9: Major Livelihood Groups in Study Villages

Occupation Wise Household Distribution		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Farmer	N	26	18	28	7	12	1	92
	%	36.1%	25.0%	49.1%	14.3%	14.3%	2.2%	24.2%
Fisher	N	27	32	10	3	20	10	102
	%	37.5%	44.4%	17.5%	6.1%	23.8%	21.7%	26.8%
Wage labor and others	N	19	22	19	39	52	35	186
	%	26.4%	30.6%	33.3%	79.6%	61.9%	76.1%	48.9%
Total	N	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Likelihood Ratio		Value= 51.282, df= 10, p=.000						

Source: Questionnaire Survey, June-October, 2016

[9] Bangladesh Bureau of Statistics, *Statistical Yearbook of Bangladesh 2011*. 31st ed. Bangladesh Bureau of Statistics, Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh (Dhaka: September 2012).

Farmer

Among the surveyed households farmers are one of the largest groups with 24.20% of total households. In farmer group there are two types are found as small and large farmer. But the portion of small farmers is higher. Different earlier studies reveal that in past few decades many large and medium farmers have turned into small farmer category in coastal zone because of the fragmentation of land due to increasing population and natural course of pauperization. Hence, number of small farmer increase and number of medium and large farmers sharply declined in coastal zone.[10]

The present study finds that farmer is the largest livelihood group in Lalua with 49.10% households, 36.10 % in Munshigonj and 25.0 % in Gabura union. The position of the rest three unions are 14.3%, 14.3% and 2.2% for Nilgonj, Khurushkul and Bharuakhali respectively. It reveals that interior unions are predominantly agro-based, majority of the respondents are directly or indirectly dependent on agriculture. On the other hand, shore line unions are not dominantly dependent on agriculture like Inland union. Hence, proportion of farmer group is relatively less.

Fishers

Number of fisher household is approximately 2.65 million in coastal zone as a whole, which is 8% of total rural farm households in Bangladesh. In general it is 14 % of total coastal rural households in Bangladesh. Fishers are extremely poor and about 70 % of them are fall in small farmers category. Fish fry collectors are the subcategory of fisher livelihood group. About half million people in coastal zone is fry collector. To a large extent fry collectors depend on shrimp sector, which contributes 41% of household income.

This study finds that fisher is the second largest livelihood group with 26.80 % of households among the study villages. In the case of individual union 37.50%, 44.4%, 17.5%, 6.1%, 23.8%, 21.8% households in Munshigonj, Gabura, Lalua, Nilgonj, Khurushkul and Bharuakhali respectively belongs to fisher livelihood group. It reveals that number of fisher group is significantly higher in coastline union. On the other hand, among the fisher livelihood group about 44% depends on fry collection for livelihood.

---

[10] PDO-CZMP, *Where Land Meets The Sea: A Profile of the Coastal Zone Of Bangladesh (Dhaka*: The University Press Limited, 2004c), 11.

Fishermen usually catch fish all the year round, but there is seasonal variation in availability of fishes in rivers and sea. The fishermen who go for deep sea fishing usually catch all the year round. While small scale fishers usually catch fish from May to November. Mid of November to Mid of April is lean period for them. During that time they usually engage in wage labor activities, repairing boats and nets, and agricultural activities.

Major risks identified by this group are cyclone, storm surge, *dadon*, and *mahajani* system of borrowing. In fisher group fish fry collectors are most subsistence sub-group usually collect fish fry during mid-December to June. Majority of the fry collectors are younger women and children. Few men those do not have own boat and net also engage in fry collection. In general fry collectors usually earn 180-220 BDT per day, while amount of earning is lower for women. This fry collector group is mostly found in Gabura, Lalua Bharuakhali union which are adjacent to sea. In interior union like Munshigonj, Nilgonj and Khurushkul where women's participation in fry collection is comparatively less. Major risks hinder livelihoods of poor fry collectors are cyclone, storm surge, dadon and mahajani system, poverty and child labor.

Wage Laborer

Wage laborer refers to the livelihood group whose primary source of income is obtained from either working as an agricultural or non-agricultural labor. Like other parts of the country majority of the rural wage laborers are involved in agricultural activities. In coastal Bangladesh number of agricultural labor household is 1.81 million, which is 33.2 % of total coastal households. Among the wage laborer 55 % belongs to small farmer and 43% landless.

Present study finds that 48.90 % of total households are wage laborer category. Number of wage laborer is higher in Nilgonj (79.6%) union than Bharuakhali (76.1%) and Khurushkul (71.9%) villages. In Cox's Bazar Sadar upazilla most of them are employed in salt industry. Wage laborer livelihood group is higher in these areas because of village's agricultural economy. Majority of the wage laborers are small farmer or landless. Natural resources (capital) of this village offer very limited options for poor villagers apart from working as wage laborer.

Whereas, in Gabura and Lalua union vast natural resources (open water bodies and forests) offers several choices for villagers, such as independent entrepreneurships for fishing either in small or large scale. Hence, number of wage laborer is found in limited scale in these unions. Wage laborer usually work all the year round. However, there is variation in availability of works. Average per day earning is 120 to 150 BDT.[11] November to February is lean period for wage laborers in coastal villages because of less availability of work in agricultural field and non-availability of fishes in rivers. Major risks hinders their livelihoods are poor transportation network in coastal zone, poor wages, uncertainties in getting job every day and illness.

6.6 Major Livelihood Affecting Adversity and Crisis in the Study Unions

The coastal zone of Bangladesh is highly prone to various natural and manmade hazards, and all such hazardous events have substantial impacts on coastal livelihoods. Almost every year coastal population experience damage of assets, crops, poultry, livestock, houses and livelihoods as well by cyclone, coastal flooding, tidal surge, coastal erosion and so on. Cyclone is most common form of hazard in Coastal Bangladesh, and strike on an average every two to three years. Southern part of Bangladesh is surrounded by the Bay of Bengal, any cyclone form in the sea always accompanied by storm surge. Any surge strikes the land always causes a large impact on coastal population’s livelihoods. The cyclones cause devastation of agricultural production, damage houses and other infrastructure and resulted in deaths. Coastal Erosion is a key problem, as most of the lands are active delta, recently inhabited and cultivated is being worn out due to normal water movement and coastal flooding (table 6.10).

[11] Questionnaire Survey, FGD, 2016.

Table 6.10: Major Adversity and Crisis in a Year in the Study Unions

Adversity	Cyclone adversity	Storm surge adversity	Flood adversity	Riverbank Erosion adversity	Salinity adversity	Deforestation adversity	Crop Damage adversity	Fish Damage adversity	Disease adversity
N	380	380	380	380	380	380	380	380	380
Mean	4.7316	2.6921	3.3658	3.7789	4.2579	3.4868	3.8132	2.5237	3.3158
Std. Deviation	.63041	1.57065	.48229	.59335	1.18558	.92593	1.22392	.88789	.70074
Variance	.397	2.467	.233	.352	1.406	.857	1.498	.788	.491
Rank	1	8	6	4	2	5	3	9	7

Source: Questionnaire Survey, June-October, 2016

Considering these multiple vulnerabilities in the coast, an attempt has been in this study to identify the major adversity and crisis households usually face in six selected study unions. This study finds that the respondent identified cyclone as a major impediment in all six areas by value 4.73. Secondly, salinity adversity was identified as a major hazard by the respondents of study area. It is because while cyclone strikes always accompanied by storm surge in coastal zone. Salinity intrusion is a major problem was identified by the almost of all respondents in study area. During dry season soil salinity become a severe problem for agriculturists, which further accelerated due to shrimp cultivation. In addition, some other problems were identified by the villages in all six locations are the results of cyclone, storm surge or salinity intrusion, such as loss of fruit trees, loss of agricultural productions, loss of fish productions and illness of inhabitants. Moreover, some other adversities such as flood, coastal erosion and sand deposition on agricultural land were identified by few respondents. Illness of inhabitants was identified by the respondent irrespective of village location, while coastal flooding and sand deposition on agricultural land is identified as problems in coastal areas.

6.7 Income Diversification

There is a close relationship between livelihoods of the coastal people and vulnerabilities, because the way of livelihood earning of one class became the catastrophes to others. Although effect of different natural catastrophes such as flood, cyclone, tidal surge etc. are common for all but coping with these is quite different among different class of people, as the coping capacity is a function of the asset base (both ownership and access too). The poor are more vulnerable as their asset base is weak and scanty.

Income diversification at household level is not a new phenomenon in coastal villages. This study finds that farmer in all the study villages are not only engage in agriculture but also simultaneously engage in fishing, animal husbandry, and selling of crops, coconut, betel nut and dairy products etc. Due to the subsistence character of income earning at household level majority of small farmer and subsistence fisher involves in wage laboring in addition to the primary occupation. However, such process of income diversification of rural households has further been taken place rapidly due to the changes in demographic characteristics like increasing population and migration and cultural transform in rural societies such as occupational diversity, women's participation in economic activities etc. However, such changes are exemplified by people's increasing involvement in various income earning activities, involvement in other's occupational domain such as farmer to seasonally fishing and women's increasing engagement in income earning activities apart from house work (such as food or cash for work) which changes traditional livelihood pattern of coastal areas.[12]

6.8 Chapter Summary

This chapter presents the measurement livelihood capitals, identifies major livelihood groups and distribution of various livelihood capitals among the six sampled unions and livelihood groups, and finally presents the livelihood assessment of coastal households. The present study identifies three major livelihood groups such as farmer, fisher and wage laborers. Distribution of livelihood capitals among six unions reveals significant differences.

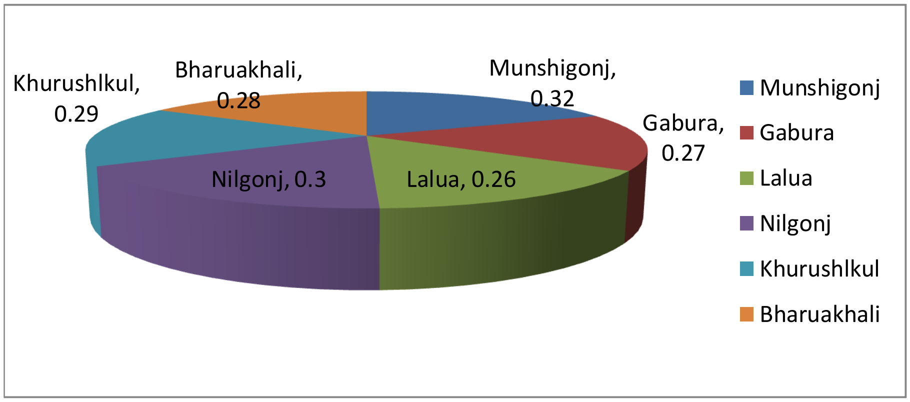
Table 6.11: Comparative Aspects of Livelihoods in Six Study Unions

Variables	Study Unions					
	Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali
Level of Aggregate Livelihood Capitals Index Value (0-1)	0.32	0.27	0.26	0.30	0.29	0.28
Major Livelihood Activities	Agriculture and allied	Fishing and allied	Fishing and allied	Agriculture and allied	Agriculture and allied	Fishing and allied
Minor Livelihood Activities	Fishing and allied	Agriculture and allied	Agriculture and allied	Wage labor and allied	Wage labor and allied	Fishing and allied
Vulnerability of Livelihoods to Climate Change	Moderate vulnerability to SLR with associated storm surge, Salinity, etc.	Very high vulnerability to SLR with associated storm surge, Salinity, Inundation etc.	Very high vulnerability to SLR with associated storm surge, Salinity, Inundation etc.	SLR with associated storm surge, Salinity, Inundation etc.	Salinity intrusion, Coastal Inundation etc.	Storm surge, Salinity, Coastal Inundation etc.
Level of Risk of Livelihoods	Moderate risk	Very high risk	Very high risk	Moderate risk	Moderate risk	High risk

Source: Comparative aspects of livelihoods in six study unions made on the basis of Questionnaire Survey, June-October, 2016

[12] PDO-CZMP, *Where Land Meets The Sea: A Profile of the Coastal Zone Of Bangladesh,(* Dhaka: The University Press Limited, 2004a), 319.

Figure 6.2: Level of Aggregate Livelihood Capitals Index Value (0-1)



Source: Questionnaire Survey, June-October, 2016

Unions which are situated nearer to sea (Gabura, Lalua and Bharuakhali) are identified having less livelihood capitals than interior unions, though natural capital for this union is relatively higher. Because of scarcity of other capitals hinders the proper utilization of the potentials of natural capital for the union like Gabura and Lalua.

Social capital for these unions is significantly lower among than other unions, which unveils relatively lesser social coherence of Lalua and Gabura which is most important to survive in disaster situation. As most of the inhabitants in these unions are the immigrants from interior locations, thus social bonding is relatively less. Likewise, among the livelihood groups, wage laborers having less livelihood capitals than farmer and fishermen. Major adversity and crisis of various livelihood groups and sub-groups are also identified in this chapter. Majority of the households irrespective of their dwelling location identified cyclone as a major adversity which significantly destroy their livelihoods. Besides this more other adversities like storm surge, salinity etc. which are also identified as the livelihood disrupting events in this climate vulnerable coastal zone.

Similarly, this study also finds that most of the coastal households are not dependent only on single income earning activities. Households in study villages diversify income sources wherever possible and most importantly while face the crisis. Such diversification of income earning activities unveils the transformation process of traditional typical coastal livelihoods. In general livelihoods of Gabura and Lalua unions which are situated at remote location and nearer to sea are more vulnerable to climate change induced hazards like cyclone, storm surge, salinity intrusion etc. While as a livelihood group wage laborer and fish fry collectors are most vulnerable following any hazard events.

Chapter Seven
Coping and Adaptation to Potential Impact of SLR

7.1 Introduction

This chapter is planned to identify the factors that are associated with the coastal people's preference for adaptation against the likely impacts of climate change induced sea level rise (CC-SLR). The basic strategies of adaptation are adaptation *in situ* and retreat. Adaptation *in situ* means adapting in current place without permanently moving elsewhere. There are two forms of in situ adaptation i.e. without changing occupation and with change in occupation. Retreat means dislocation, migrate out or permanent evacuation to relocate elsewhere.[1] Given the plausible future scenario of climate change induced sea level rise (SLR) it is predicted that the natural resource-based livelihood would be affected due to increased salinity in soil, sub-soil water table and in surface water bodies. The most dominants livelihood earning opportunities such as agriculture, fishing and other on-farm activities will be seriously affected by this which may have serious repercussion ultimately on future food and livelihood security.[2]

SLR is considered to be the most important factor which may redefine the socio-economic landscape of the entire coastal zone. Because, how coastal people may respond against the impacts of SLR that will largely determine the future course of their lives. At private level the ultimate options to respond to SLR are very limited, i.e. either stay at current place (often labelled as adaptation *in situ*) through increasing resiliency and adaptive capacity or move away back (i.e. out migration). In the coastal area of Bangladesh Previous experience shows that people are highly adaptive although there were occasional out migration. However, salinity intrusion, coastal inundation may take the form of a permanent nature from a seasonal problem, many low lands, farmlands, settlements, and other public infrastructures would be abandoned eventually.

All these indicate that response such as adaptation *in situ* against the future vulnerability will be more complicated than any time in the past which may set off huge out migration.

---

[1] R.T. Klein and R.J. Nicholls, "Assessment of Coastal Vulnerability to Climate Change," *Ambio*28, no.2 (1999): 182.

[2] World Bank, *Bangladesh: Climate Change and Sustainable Development*, *Report No. 21104-BD*, Rural Development Unit, South Asia Region, The World Bank, Dhaka (2000): 95.

As Bangladesh is already highly populated it would be very hard to relocate millions of SLR refugees in further inland. Policy makers and planners need to devise mechanism to holdback peoples likely to retreat back. For this, the starting point could be characterization of the vulnerable people who are more likely to be SLR refugees.

This study through its qualitative assessment of the influences of various factors on peoples' preference for adaptation *in situ* against SLR, gives the answer why some people more likely to prefer adaptation *in situ* while others prefer permanent retreat from the coastal zone of Bangladesh. The result of the study will add value in the existing form of knowledge related to SLR refugees.

Coping response discloses individual's perceptions and efforts to manage resources for mitigating the unfavorable outcomes of hazards. Managing of resources implies how it is done in unexpected and adverse situations. Coping usually starts while household is required to mobilize its assets to respond to crisis; such as consume savings, assets disbursement, borrowing from kin and patrons etc. Coping strategies will be successful when household is capable to distribute resources to overcome crisis without compromising with long term objective of livelihood security.

In contrast, coping may fail when all efforts to overcome crisis are unsuccessful. This study finds that people in six coastal areas developed their own coping strategies in response to SLR impact which are distinct in character as compared to other regions of the country. Based on the context, the adoption of a particular set of strategies depends on people's cultural and socio-economic background, physical location, the characteristics of hazards, the level of individual's vulnerability, access to livelihood capitals and ability to absorb shock.

7.2 Defining Adaptation and Concept

Adaptation is change in natural or human systems in response to actual or expected climatic effect, which moderates harm or exploits beneficial opportunities.[3] Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation.

Adaptation is useful steps to protect countries and communities from the likely disruption and damage that will result from effects of climate change. For example, flood walls

[3] R.T. Klein and R.J. Nicholls, "Assessment of Coastal Vulnerability to Climate Change," *Ambio*28, no.2 (1999): 183.

should be built and in many cases it is probably advisable to move human settlements out of flood plains and other low-lying area.

In climate change literature several definitions of adaptation are found, mostly variations on a common theme. It describes adaptation as ‘‘adjustments in a system’s behavior and characteristics that enhance its ability to cope with external stress". In the climate change context it refers to adaptations as "adjustments in ecological-socio-economic systems in response to actual or expected climatic stimuli, their effects or impacts."[4] It also defines in the climate context that adaptations as the "adjustments in individual groups and institutional behavior in order to reduce society’s vulnerability to climate."[5]

Finally it can be explained that adaptation is a very broad process, which can be categorized into components according to who or what adapts, the timing of adaptation, its motive, and many other factors.[6]

7.3 Strategy and Approach to Successful Adaptation

There is a lack of agreement about what constitutes successful adaptation. Successful adaptation will be seen on multi-decadal timeframes based on the achievement of development objectives responsive to a changing climate. However, the assessment of such long-term achievements would require monitoring and evaluation. However, it seems that evaluations of adaptation at all scales should include elements of effectiveness, flexibility, efficiency, equality and sustainability.

7.3.1 Adaptation Measures Proposed by IPCC

IPCC has extensive works on climate change related disaster and formulated different adaptation measures for vulnerable communities. Different measures are applicable in different time and space. Various adaptation measures proposed by IPCC in its fourth assessment report are as following table (table7.1). It will be useful to compare these measures with currently practiced techniques in the selected study areas.

---

[4] Barry Smit and Mark W. Skinner, "Adaptation Options in Agriculture to Climate Change: A Typology," *Mitigation and Adaptation Strategies for Global Change* 7, no. 1 (2002): 87.

[5] *www.cires1.colorado.edu/science/groups/pielke/pubs/books/bookchapters.html (Accessed on 17 May 2017).*

[6] Ibid., 89.

Table 7.1: Adaptation Measures Proposed by IPCC

Sector	Adaptation measures proposed by IPCC
Water	Expanded rainwater harvesting Water storage and conservation techniques Water re-use and desalination Water-use and irrigation efficiency
Agriculture	Adjustment of planting dates and crop variety; crop relocation Improved land management, e.g. erosion control and soil protection Through tree planting
Human health	Heat-health action plans Emergency medical services Improved climate-sensitive disease surveillance and control Safe water and improved sanitation

Source: W. Neil Adger, Shardul Agrawala, M. Monirul Qader Mirza, Cecilia Conde, Karen o'Brien, Juan Pulhin, Roger Pulwarty, Barry Smit and Kiyoshi Takahashi, "Assessment of Adaptation Practices, Options, Constraints and Capacity," *Climate Change* (2007): 719.

7.3.2 Adaptation Options Practiced Worldwide to Reduce Sea Level Rise Impact

There are different types of adaptation options which are now currently exercised all over the world in order to reduce sea level rise impacts. Some of them are presented in following table (table 7.2)

Table 7.2: Adaptation Options Practiced Worldwide to Reduce Sea Level Rise Impact

Protect	Retreat	Accommodate
• Hard structures dykes, sea - walls, tidal barriers, detached breakwaters • Soft structures-dune or wetland restoration or creation, beach nourishment. • Indigenous options walls of wood, stone or coconut leaf, Afforestation	• Establishing set-back zones • Relocating threatened buildings • Phasing out development in exposed areas • Creating upland buffers • Rolling easements	• Early warning and evacuation systems • Hazard insurance • New agricultural practices, such as using salt-resistant crops • New building codes • Improved drainage • Desalination system

Source: W. Neil Adger, Shardul Agrawala, M. Monirul Qader Mirza, Cecilia Conde, Karen o'Brien, Juan Pulhin, Roger Pulwarty, Barry Smit and Kiyoshi Takahashi, "Assessment of Adaptation Practices, Options, Constraints and Capacity" *Climate Change* (2007): 723.

7.4 Types of CC- Induced Hydro Meteorological Hazards in Coastal Zone

The total area of the coastal zone of Bangladesh is historically prone to multiple natural hazards. The prominent of such hazards include among others coastal flooding, cyclonic storm, sea surge, salinity intrusion etc. Moreover, the localized nature of scarcity of both irrigation and drinking water due to extreme salinity is a major hazard. There are differences in the process of formation, timing of onset, duration of events, and even in devastating powers among these hazards what are common but they cause unprecedented damage of wealth, property, other human wellbeing. In fact, ultimate effects are felt on livelihood security of the coastal inhabitants.

Although a diverse occupational group is observed in the study area and most people are heavily dependent on natural resource-based livelihood yet some occupational groups are more affected by natural disastrous event. Focus group discussion and other informal conversation with the respondents unveils that impacts of climatic event with associated risks are very universal. Direct impacts are felt by the respondents irrespective of their occupational engagement. Study reveals that impacts of climatic events are felt severe if such hazardous event takes place during high tide. Respondents reported that with the increase of surge height the damage increase as well. Similarly, they experience higher damage of property and other assets if any event takes place unexpectedly.

The study reveals from FGD that unlike cyclone and storm surge, the impacts of other disastrous events are often not felt by various occupational groups uniformly. Impacts of coastal flooding, for instance, are more felt by people engaged in agriculture and other non-agriculture activities such as trading, transportation. Impacts of salinity intrusion are more felt by people engaged in agricultural and other on-farm activities. By contrast, the impacts of heavy rainfall or deep low pressure in the nearby Bay of Bengal are more felt by respondents who are engaged in fish catch and fish trading. In fact, prolong rainfall not only impedes the fish catch more importantly, however, causes problem in post-harvest processing and transportation. Day or casual laborer group is the most affected occupational group who suffer the most from any kind of disastrous events. It is partly because they have only one entitlement, i.e. physical labor which cannot be capitalized during any disastrous events.

While some disastrous events directly affect the livelihood avenues of many people, however, indirectly cause often irrecoverable damage to the livelihood of others as well. Sometimes indirect effects are more threatening than direct effects. It is because often the impacts of indirect effects are long lasting and often go unnoticed until takes the severe form. The Table 7.3 reports some of the key features of major disastrous events that ravaged the entire study areas time and again.

Table 7.3: Characteristics of Natural Disastrous Events in the Study Area

Disastrous events	Characteristics	Impacts/Affects
Salinity intrusion	**Occurrence:** • During December-April (winter period); • During high tide saline water travel further inland; • High amount of saline water penetrate to the soil and sub soil water table during winter; • Salinity remain high until next monsoon	• Destroy salinity sensitive rice seed-bed; • Interrupt transplantation/ planting of winter rice; • Interrupt the cultivation/ growth of salinity sensitive winter vegetables and legumes; • Damage the pasture land and cause shortage of fodder; • Localized crisis of fresh water both irrigation and drinking
Cyclonic storm and surge	**Occurrence:** • During April- May (pre-monsoon); • This pre-monsoon cyclones are rather less frequent and less destructive • During October-November (post-monsoon); • This post-monsoon cyclones are rather more frequent and more destructive	• Destroy the ready-to-harvest paddy; • Destroy culture fisheries; • Cause damage of settlement and dwelling units; • Cause damage of various infrastructures; • Interrupt physical mobility • Interrupt in offshore fishing
Coastal flooding	**Occurrence:** • During July-September; • When high tide synchronize with torrential rainfall; • When spring/king tide synchronize with drainage congestion; • Breach of ; • In severe cases up to three weeks.	• Destroy the rice seed-bed; • Damage the rice field during growing/flowering periods; • Damage the pasture land; • Destroy the culture fisheries; • Cause damage of various infrastructures; • Cause damage of settlement and dwelling units; • Interrupt physical mobility
Heavy rainfall	**Occurrence:** • During June-August; • Often associated with onset of Indian ocean monsoon • When synchronize with high tide causes localized flooding; • Duration varies: few hours to couple of days	• Destroy the rice seed-bed; • Damage the rice field during growing/flowering periods in low lying parts; • Interrupt the post-harvest processing of rice; • Interrupt fish-catch in the off shore; • Interrupt post-harvest processing of fish (sun-dry process). • Interrupt physical mobility

Source: Field Study, 2016.

7.5 Awareness about Climate Change for Adaptation

Climatic variation is simply variation from climate normal. Climatic variation and weather extreme form the basis for climate change. In a global scale, example of climate change/weather extreme could be-change in, global mean temperature, pattern of precipitation, amount of melting of snow and ice etc.[7] Climate change/weather extreme phenomena are often felt by people living in any area for long time due to their interaction with local environment. In fact, their familiarities are often associated with particularly important outcomes. For example, a farmer get used to preparing land at the very onset of monsoon for wet season crops can easily notice if the monsoon is deviated from their traditional mental map of seasonal calendar. Some of the climatic variation and weather extremities are really noticeable. Awareness has different implications. In disaster literature awareness means increasing levels of consciousness and perception about risks and reduction of exposure to hazards.

Perception is seen as durable and identical character of an individual which functions as the generative basis of planned adaptation. For building climate awareness, existing perception about climate change can be a determinant factor. Hence knowing people's perception about CC-SLR is just the beginning of any intervention.

In the context of adaptation against the impacts of climate change induced SLR it is immense important for the coastal community to be aware about the changing climatic events, plausible scenarios of SLR rise for different time frames and its impacts might influence their livelihood. A set of 15 questions related with obvious outcomes of CC-SLR were prepared for knowing their perception about CC-SLR.

Table 7.4: Perception about Climate Change

Perception	N	Mean	Std. Deviation	Rank
Summer is Hotter than Previous	380	4.8421	.36512	1
Long Summer Season	380	4.7605	.42732	2
Water of River, Canal are Getting More Saline than Earlier	380	4.5632	.49665	3
Frequency of Stormy Events are Increasing than Earlier	380	4.3421	.47504	4
Untimely Rainfalls are Becoming More Prevalent than Earlier	380	4.2816	.63510	5
Short Winter Season	380	4.2737	.88603	6
Overall Rainfall are Decreasing than Earlier	380	4.1789	.73336	7
Migratory Birds are Less Seen in Winter than Earlier	380	4.1211	.55426	8
Timely Rainfall are Very Rare	380	4.0237	.72786	9
Winter is Colder than Previous	380	3.9816	.29450	10
Encroachment of New Areas by High Tide	380	3.9447	.89831	11
Hard to Find 6 Seasons of a Year Now than Any Time Earlier	380	3.7658	.88099	12
Less Rainfall in Winter	380	3.6421	.81433	13
Winter Starts Less than The Normal Timing	380	3.5605	.81802	14
Unusual Formation of Fog in the Winter is Higher than Earlier	380	3.4316	.59288	15

Source: Questionnaire Survey, June-October, 2016

[7] R. S. Nerem, D. P. Chambers, E. W. Leuliette, G. T. Mitchum and B. S. Giese, "Variations in Global Mean Sea Level Associated with the 1997–1998 ENSO Event: Implications for Measuring Long Term Sea Level Change," *Geophysical Research Letters* 26, no. 19 (1999): 3005.

The present study unveils that the coastal people are aware about climate change. Respondents were asked about their perception about climate change through some indicators which are related to the event as seasonal variation, stormy events, rainfall level, presence of migratory birds, temperature variation etc. Total fifteen climate change related indicators were used to get the information. Maximum response was summer is hotter than previous followed by long summer season, salinity increase, increasing of stormy events, unusual rainfall, short winter, rainfall decreasing, migratory birds are less seen, rare of timely rainfall, colder winter, new area inundation with high tide, less seasonal variation, less rain in winter and starts late and unusual fog formation.

Information about different climatic events supports to build awareness. Respondent were asked where they have got information first related about climate change. In this context they answered about different sources.

Table 7.5: Sources of Information about the Potential Impact of SLR

Information About The Potential Negative Impact of SLR		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Educated Person	n	10	17	11	21	25	12	96
	%	13.9%	23.6%	19.3%	42.9%	29.8%	26.1%	25.3%
NGO Worker	n	34	30	17	3	10	10	104
	%	47.2%	41.7%	29.8%	6.1%	11.9%	21.7%	27.4%
Govt. Officer	n	9	6	2	3	9	4	33
	%	12.5%	8.3%	3.5%	6.1%	10.7%	8.7%	8.7%
Radio	n	17	19	27	22	40	20	145
	%	23.6%	26.4%	47.4%	44.9%	47.6%	43.5%	38.2%
TV, Talk show	n	2	0	0	0	0	0	2
	%	2.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Source: Questionnaire Survey, June-October, 2016.

From Table 7.5 it is seen that the highest number (43.5%) of respondents acknowledge that radio is the source that they use most frequently to get weather bulletin, climate new and warning information about natural disasters particularly gusty wind, cyclone, wave surge. A very significant portion of respondents (27.4%) have acknowledged that word of mouth information of community sources is very helpful indeed. They participate in these kinds of local cultural event often due to the influence of peers/relatives. No matter, how far information obtained from these informal sources is credible but they have to rely on this informal word of mouth information as well. Of course, almost 8.7% have acknowledged that they have access to direct official sources to get very up-to-date real-time information. It is probably because the second largest sub-national climate forecasting office is located at "Khepupara" (of Kalapara Upazila- sub district) which is 10 km from the study sites. People with relatively better socio-economic standing often can directly communication with officials of that office using their mobile phone to get very up-to-date information. Apart from these, other government offices and NGOs also disseminate warning information. The feature is that only 27.4% of the respondents get information from educated persons. Television could be a very powerful media to make people more aware about the disaster events including SLR and its associated events. Unfortunately, most parts of the study sites are so remote that there is no electricity; only handful of relatively well-off people can afford television operated with solar panel or battery. On an average each respondent makes use of 0.5% of respondents get information from media for preparing them to cope and adapt with upcoming disasters

Climate change-sea level rise (CC-SLR) is a different kind of issue for the coastal zone of Bangladesh. It is considerable uncertainty regarding the extent of change therefore it is fundamental to know the level of understanding of the people for who adaptation plan need to be initiated. Present study suggests that only an aware community can get involved in the process of adaptation. Frequency of occurrence of disaster is a vital option for taking steps for adaptation.

Table 7.6: Number of Hazardous Events Round the Year

Number of climatic events faced in the year	Frequency (n)	Responses (%)
a. Only one event	19	4.9
b. Two events	51	13.3
c. Three events	143	37.2
d. Four event	138	35.8
e. Five events	34	8.8

Note: Multiple responses

Source: Questionnaire Survey, June-October, 2016

In the present study an attempt has been made to gather how many disastrous events generally the respondents face round the year. 37.2% respondents face three events, 35.8% respondents face four events of disaster which were assessed through multiple responses. 4.9%, 13.3%, 8.8% responses face one, two and five events respectively.

7.6 Coping and Adaptive Measures to Secure Livelihoods

The coastal people have been coping and adapting against various disastrous events time and again. They have developed various sets of coping and adaptive measure to secure their lives and livelihood. Some coping and adaptive measures are very common, i.e. used for multiple situations; some are used by them in specific conditions.

The coastal livelihood opportunities are broadly two types i.e. agriculture and allied occupation, and non-agriculture and similar occupations. The people of the region take different and diverse steps to cope with the adverse situations, sometimes take multiple coping and adaptive measures. People engaged in agricultural activities usually employ multiple measures. They have their own cropping calendar which includes the suitable time of land preparation, seed-bed preparation, transplantation, irrigation, growing, flowering, maturing, harvesting, post-harvest processing and storing. They usually frame all these stages of cropping cycle based on natural season. Following day to day weather they have to adjust timing of some of these activities of cropping cycle.

They have to cope and adapt with abnormal timing of rainfall. For example, in the event of early monsoon they use their relatively uplands for seed-bed preparation to avoid damage or failure of seed-bed that might result from water logging. On the contrary when they suspect late monsoon they use their only lowland for seed-bed preparation. However, their total cropping cycle is heavily affected if late monsoon is taken place with flood-water usually comes from upper catchments. In such a case most of the farmers experience either partial or complete damage of transplanted growing plants. To cope with this situation they often go for replanting. Some cases they simply leave abandoned. If rainfall is on time they usually have a good harvest. But that is not usual case and occurs rarely.

Most of the cases rainfall is delayed and sometimes even synchronize with flood that damages the transplanted rice field. Although many farmers go for replanting, however, they encounter one more deadly event i.e. storm surge which washes away mature paddy waiting for harvest. This is usually happened in the month of November/December. To cope with this devastating situation they go for early harvesting of paddy. Adaptation strategies are different for the time and intensity of the event. SLR is a different type of event and the impact will not be felt immediately. In different phases the intensity of SLR impact will be dissimilar in from. In that case adaptation strategies will be varied.

Different types of adaptation measures practicing by communities and institutions have been identified by questionnaire survey and FGDs during field survey. Different institutions involved in adaptation process in the six selected unions of study area. They are two types, as given below

a. Indigenous practice of Adaptation and
b. Institutional Initiative of Adaptation (GO, NGO and CBO)

7.6.1 Indigenous Adaptation Practices in the Study Areas

To address the research questions stated in the introduction part about adaptation, a semi-structured questionnaire was prepared with relevant indicators and tested in the study area before conducting the actual field survey. The questionnaire included among others various adaptive information of the family, their exposure to various disasters, the damage that they experience due to repeated disasters, their perception about the changing nature of climate, extreme events and sea level rise, and the likely impacts of these events on their live and livelihood. The respondents were finally asked how they will face the upcoming adversity in different scenarios of SLR. The following steps were followed to carry out the survey and data processing.

The respondents were interviewed for present practices. The likely scenarios of SLR for the year 2020–2030, 2050–2075 and 2100 were narrated in brief before taking interview of the respondents. The direct impacts that might result from such SLR were also shared with them before the start of the interview. Respondents were asked to narrate the ways about adaptation. They were further asked, what they or their future generation would probably do if their livelihood becomes insecure due to the impacts of future SLR and its associated events. From numerous responses, ultimately the likely occurrence of forced migration from the coastal tract was counted. The respondents were asked to find sources of livelihood insecurity that might help them to resilient in the fragile coast.

The respondents were asked to identify appropriate measures to reduce their livelihood vulnerability. Accordingly they were provided some measures for maximization of adaptive capacity. These lists of measures were prepared based on review of both hazard and climate literature. Broadly, these measures include supportive measures that have the potential to improve the negative impacts of SLR and its associate events on the livelihood of coastal people. Different indigenous adaptive measures against the impact of sea level rise which the coastal people of the study area have been stated below

7.6.1.1 Adaptation Measures for Agriculture due to Salinity Intrusion in Different Scenarios SLR

Saline intrusion problem is serious in almost all parts of exposed coastal part of Bangladesh. Saline water remains in all types of land all the year round. In coastal area, the situation becomes more critical in October-March due to heavy saline water enters into the village become logged. Due to salinity crop production decreases, fruit tree dies, reduces fish, and increases different diseases. As sea level rises, water enters into the village through sluice gate in normal season. Almost all the unions are more or less affected by salinity.

Saline water is entering into the village causes severe problem in agricultural sector. Previously, salinity remained for 3 months but now it remains for 6 month. Salinity increases but poor people living in the coastal zone don't have any control on it. According to participants in FGD, whole study area is more or less affected by salinity.

Fertility of Lands of coastline area day by day decreasing sea level rise will trigger up the situation of increasing salinity. As a result agricultural sector is seriously threatened. According to local participants almost all the areas are affected by salinity in different places but the agro land located beside the river and channels are the most affected by salinity (FGD, 2016). The respondents were asked what they would do in different projected scenarios of Sea level rise.

The study reveals that the respondents are not very anxious about present situation as 64.47% responses were normal management for agriculture. Some responses were conventional agriculture, irrigation management as 25%, 5.7% respectively.

For the situation of 2030, the study finds that flood and salinity tolerant crops are the best responses for adaptation regarding salinity as 24.32% followed by 16.99% time of cultivation change and 1.93% for pattern of cultivation change were the best responses comparatively.

It reveals that for the situation 2050, the highest response was for high yield crop verities as 20.91% followed by Salinity tolerant crops as 18.25%. Salinity management for 2100 situation, regarding sea level rise most of the respondents answered with uncertainty about management (table 7.7).

Table 7.7: Adaptation Measures for Agriculture due to Salinity Intrusion in Different Scenarios SLR

Present Management for Salinity		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Conventional Agriculture	f (%)	12(21.1%)	3(5.3%)	11(19.3%0	23(.5%)	11(19.3%)	18(31.6%)	57(25%)
Land use pattern Change	f (%)	4(30.8%)	0(0.0%)	6(46.2%)	3(23.1%)	0(0.0%)	0(0.0%)	13(5.7%)
Irrigation management	f (%)	2(18.2%)	0(0.0%)	6(54.5%)	3(27.3%)	0(0.0%)	0(0.0%)	11(4.8%)
Normal management	f (%)	18(12.2%)	22(15.0%)	10(6.8%)	31(21.1%)	43(29.3%)	23(15.6%)	147(64.5%)
Total		36	25	33	39	54	41	228
Salinity Management for 2030								
Flood & Salinity tolerant Crops	f (%)	12(19.0%)	0(0.0%)	17(27.0%)	5(7.9%)	11(17.5%)	18(28.6%)	63(24.32%)
Timing of Cropping	f (%)	2(4.5%)	0(0.0%)	11(25.0%)	2(4.5%)	11(25.0%)	18(40.9%)	44(16.99%)
Change in Cultivating Pattern	f (%)	2(40.0%)	3(60.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	5(1.93%)
Others	f (%)	18(12.2%)	22(15.0%)	10(6.8%)	31(21.1%)	43(29.3%)	23(15.6%)	147(56.76%)
Total		34	25	38	38	65	59	259
Salinity Management for 2050								
High yield crop verities	f (%)	10(18.2%)	3(5.5%)	11(20.0%)	2(3.6%)	11(20.0%)	18(32.7%)	55(20.91%)
Salinity tolerant crops	f (%)	6(12.5%)	0(0.0%)	11(22.9%)	2(4.2%)	11(22.9%)	18(37.5%)	48(18.25%)
Others	f (%)	22(13.8%)	22(13.8%)	16(10.0%)	34(21.3%)	43(26.9%)	23(14.4%)	160(60.83%)
Total	Count	38	25	38	38	65	59	263
Salinity Management for 2100								
Unknown	f (%)	32(14.9%)	25(11.6%)	27(12.6%)	36(16.7%)	54(25.1%)	41(19.1%)	215(100%)
Total		32	25	27	36	54	41	215

Note: Multiple Response Analysis

Source: Questionnaire Survey, June-October, 2016

7.6.1.2 Adaptation Strategies for Crops Management in Different Scenarios of Potential Impact of Sea Level Rise

Major portions of population in coastal area of Bangladesh depend on agriculture for livelihood security. The impact of sea level rise situation in different situation can potentially destroy land based production system as has been observed in the selected areas. Therefore, SLR particularly influences continuation of poverty, especially among those who are in small farmer group.

The study reveals according to the respondents information during household survey, the temperature has increased over the years and duration of winter has been shortened affecting the potential growing period of winter crops. Climate change has another impact on cultivation of wheat is being affected at grain filling stage due to high temperature and increased incidences of pests and diseases. Increased intensity of soil salinity was perceived by the farmers as white crust of salts on soil surface and crop burning during drier months in the study areas. In recent time farmers of coastal area very concerned about climate change issues as erratic rainfall, temperature rise, short winter, intensity of drought, salinity, tidal surges, submergences, cyclone, tornadoes etc. in crop production systems. Increasing of salinity by sea level rise will significantly decrease the crops production and threaten livelihood security.

During field visits, survey, FGDs, and discussion with local experts, extension personnel and farmers in evaluating the severity of SLR risk factors affecting crop production systems it is found that there is negative impact on crop production in different situation of sea level rise. To reduce the intensity of impact the respondents were asked to find the possible measures of the study area. During evaluation of crop losses, major SLR induced risk factors were also identified. Agriculture is mainly production of rice oriented. For present time the responses for local paddy verities (BR 10, 11, 23, BRRI 28, 30) is highest as 60.77% followed by Purbashi, Jamai Babu as 32.04%. For situation 2030 BRRI 41, 49 hold highest response followed by Lal Teer, Khaja lota, Chaina 39.55%. Crops adaptation for 2050 they responded for BRRI 40, 47 as 43.43% followed by Heera, Shahab Kachi, Mala gati, Sada Gutal, Bina and Bina 7,8,9 as 22.22%, 1.01% respectively. For 2100 situation they responded Kajol shail, Hummi, Nonakochi as 37.83% and 62.16% responses were in uncertainty (table 7.8)

Table 7.8: Adaptation Strategy for Crops Management in Different Stages of Potential Impact of Sea Level Rise

Present Management of Crops		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Local paddy verities (BR 10,11,23,BRRI 28,30)	f (%)	24(21.8%)	24(21.8%)	22(20.0%)	8(7.3%)	13(11.8%)	19(17.3%)	110(60.77%)
Purbashi, Jamai Babu	f (%)	14(24.1%)	17(29.3%)	19(32.8%)	5(8.6%)	2(3.4%)	1(1.7%)	58(32.04%)
Unknown	f (%)	0(0.0%)	3(23.1%)	0(0.0%)	6(46.2%)	0(0.0%)	4(30.8%)	13(7.18%)
Total		38	44	41	19	15	24	181
Crops Management for the Scenarios of 2030								
BRRI 41,49	f (%)	10(15.9%)	4(6.3%)	17(27.0%)	3(4.8%)	11(17.5%)	1(28.6%)8	63(47.01%)
Lal Teer, Khaja lota, Chaina	f (%)	14(26.4%)	17(32.1%)	11(20.8%)	8(15.1%)	2(3.8%)	1(1.9%)	53(39.55%)
New Saline tolerant crops	f (%)	2(11.1%)	6(33.3%)	(0)0.0%	6(33.3%)	0(0.0%)	4(22.2%)	18(13.43%)
Total		26	27	28	17	13	23	134
Crops Management for the Scenarios of 2050								
BRRI 40,47	f (%)	18(20.9%)	17(19.8%)	11(12.8%)	8(9.3%)	13(15.1%)	19(22.1%)	86(43.43%)
Heera, Shahab Kachi, Mala gati, Sada Gutal, Bina	f (%)	6(13.6%)	0(0.0%)	6(13.6%)	3(6.8%)	11(25.0%)	18(40.9%)	44(22.22%)
Bina 7,8,9	f (%)	2(100.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	2(1.01%)
New Saline tolerant crops	f (%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	2(1.01%)	2(100.0%)
Total		32	27	29	29	34	47	198
Crops Management for the Scenarios of 2100								
Kajol shail, Hummi, Nonakochi	f (%)	6(8.6%)	0(0.0%)	3(4.3%)	3(4.3%)	22(31.4%)	36(51.4%)	70(37.83%)
Unknown	f (%)	22(19.1%)	27(23.5%)	20(17.4%)	23(20.0%)	12(10.4%)	11(9.6%)	115(62.16%)
Total		28	27	23	26	34	47	185

Note: Multiple Response Analysis

Source: Questionnaire Survey, June-October, 2016

7.6.1.3 Adaptation Measures for Fisheries in Different Scenarios of Potential Impact of Sea Level Rise

Among other livelihood options coastal fisheries is very vital option for coastal people. Coastal fisheries are seriously affected by sea level rise. It is happened in three ways; by salinity, by flooding and by increasing cyclone frequency and damage. These three factors collectively decrease the coastal fisheries.

Sea level rise has extensive impact on the physiography of the river estuary, causing a great change in fish habitat and breeding ground. Sea level rise is helping shrimp farming by introducing salinity in the coastal area, but it is also harmful. If we consider another sea level rise phenomena, for instance flooding; it is doing massive harm to the sector by overflowing shrimp pond and let the shrimps to set free in open water.

Fisheries are the main protein source for the people of coastal area. About 60- 80 per cent of animal protein intake of the people comes from fish consumption.[8] So, decreased coastal fisheries would cause protein scarcity among the population of study area that ultimately causes health hazards. Poor health status will gear up poverty in this area. At the same time poverty will boost up health hazards because of lacking sufficient medicine, health care and nutrition. If the coastal fisheries decrease, it will hinder Bangladesh from earning foreign exchange, as because the frozen food industry, the second largest foreign exchange earner sector of Bangladesh, is dependent on coastal fisheries. Insufficient foreign exchange earnings will also increase poverty. Increased poverty will cause Bangladesh to seek foreign aid.

The respondents were interviewed about different measures of fisheries in terms of different scenarios of SLR. For the present management they answered about cultivation in internal pond, local fish, cultivation in normal time as 47.13%, 43.60%, 9.26% respectively. For 2030 strategies are cultivation in internal and open pond, local tolerant fish, change in management as 62.50%, 15%, 19.55% respectively. For 2050, the responses of strategies are risk free shallow water cultivation, saline tolerant fish, cultivation in changing time as 53.85%, 32.97%, 6.60% respectively. For 2100, the responses of the strategy is highly saline tolerant fish as 23.1% (table 7.9).

Table 7.9: Adaptation Measures for Fisheries in Different Scenarios of Potential Impact of Sea Level Rise

Present Management for Fishery		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Cultivation in Internal pond	f (%)	45(26.0%)	58(33.5%)	19(11.0%)	15(8.7%)	25(14.5%)	11(6.4%)	173(47.13%)
Local Fish	f (%)	43(26.9%)	55(34.4%)	19(11.9%)	11(6.9%)	25(15.6%)	7(4.4%)	160(43.60%)
Cultivation in Normal Time	f (%)	9(26.5%)	7(20.6%)	4(11.8%)	2(5.9%)	12(35.3%)	0(0.0%)	34(9.26%)
Total		97	120	42	28	62	18	367
Fishery Management Strategy for 2030								
Cultivation in Internal and open pond	f (%)	30(24.0%)	38(30.4%)	14(11.2%)	10(8.0%)	23(18.4%)	10(8.0%)	125(62.50%)
Local Saline Tolerant Fish	f (%)	8(26.7%)	4(13.3%)	4(13.3%)	2(6.7%)	12(40.0%)	0(0.0%)	30(15%)
Change of Cultivation Time	f (%)	3(50.0%)	3(50.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	6(3%)
Change in management	f (%)	5(12.8%)	7(17.9%)	1(2.6%)	10(25.6%)	10(25.6%)	6(15.4%)	39(19.55%)
Total		46	52	19	22	45	16	200

[8] Md Ferdous Alam and Kenneth J. Thomson, "Current Constraints and Future Possibilities for Bangladesh Fisheries," *Food Policy* 26, no. 3 (2001): 298.

Fishery Management Strategy for 2050								
Fisheries in Risk free Shallow Water	f (%)	13(26.5%)	11(22.4%)	4(8.2%)	2(4.1%)	15(30.6%)	4(8.2%)	49(53.85%)
Saline Tolerant Fish	f (%)	5(16.7%)	10(33.3%)	0(0.0%)	4(13.3%)	3(10.0%)	8(26.7%)	30(32.97%)
Cultivation in Changing Time	f (%)	3(50.0%)	3(50.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	6(6.60%)
Total		24	27	4	6	18	12	91
Fishery Management Strategy for 2100								
Highly Saline Tolerant Fish	f (%)	3(23.1%)	3(23.1%)	--	--	3(23.1%)	4(30.8%)	13(100%)
Total		3	3	--	--	3	4	13

Note: Multiple Response Analysis

Source: Questionnaire Survey, June-October, 2016

7.6.1.4 Adaptation Measures for Settlement in Different Stages of Potential Impact of Sea Level Rise

It is found in household questionnaire survey and FGD that other than food and employment security, poor households experience many other forms of vulnerability due to sea level rise condition. Poor people's houses are naturally poorly built, which rot during prolonged inundation. Sea level rise induced river erosion swept away many household into river. Roads and other physical infrastructures are severely damaged in coastal inundation/tidal surge and river erosion. Earthen walls are completely destroyed even in one tidal surge/coastal inundation and river erosion event and the family members become homeless. Poor and marginal people find it difficult economically to reconstruct their houses, fully knowing that their efforts will again be destroyed in the future SLR induced inundation and river erosion period. During questionnaire survey, about 95% people agreed that housing is the most vulnerable sector due to SLR impacts in all the six selected study unions.

About 98.72% houses (includes semi-pucca, kutcha and jhupri) of the study area cannot resist disasters (particularly river erosion, storm surges and inundation). Pucca houses, about 1.28% mainly includes cyclone shelters, schools, union council, forest office and several NGOs offices. Sea level rise induced inundation might create potential insecurity on settlement of coastal area. In this context the respondents were interviewed about their management regarding settlement in different scenarios of sea level rise. Presently their management responses are for normal area, normal foundation, forestry around the shelter as 66.90%, 23.60%, and 9.51% respectively. In present situation they are not anxious about settlement. For 2030, the strategies are change in base foundation, safe area, change in construction material as 62.39%, 37.16%, 46% respectively. For the management of 2050, responses are raise base foundation, safe area, change in structure, forestry around the shelter as 55.67%, 42.65%, .42%, 1.26% respectively. Sea level rise scenario for 2100, the responses are extra raise base foundation, unknown as 37.02%, 62.98% respectively (table7.10).

Table 7.10: Adaptation Measures for Settlement in Different Scenarios of Potential Impact of Sea Level Rise

Present Management for Settlement		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Normal Area	f (%)	72(18.9%)	72(18.9%)	57(15.0%)	49(12.9%)	84(22.1%)	46(12.1%)	380(66.90%)
Normal Foundation	f (%)	21(15.7%)	18(13.4%)	14(10.4%)	18(13.4%)	46(34.3%)	17(12.7%)	134(23.60%)
Forestry Around the Shelter	f(%)	9(16.7%)	7(13.0%)	7(13.0%)	15(27.8%)	10(18.5%)	6(11.1%)	54(9.51%)
Total		102	97	78	82	140	69	568
Settlement Management Strategies for 2030								
Change in Base Foundation	f(%)	39(14.3%)	32(11.8%)	36(13.2%)	41(15.1%)	79(29.0%)	45(16.5%)	272(62.39%)
Safe Area	f(%)	42(25.9%)	47(29.0%)	28(17.3%)	23(14.2%)	15(9.3%)	7(4.3%)	162(37.16%)
Changes in construction Material	f(%)	2(100.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	2(.46%)
Total		83	79	64	64	94	52	436
Settlement Management Strategies for 2050								
Raise Base Foundation	f(%)	54(20.4%)	51(19.2%)	48(18.1%)	32(12.1%)	51(19.2%)	29(10.9%)	265(55.67%)
Safe Area	f(%)	42(20.7%)	49(24.1%)	37(18.2%)	19(9.4%)	29(14.3%)	27(13.3%)	203(42.65%)
Changes in Structure	f(%)	2(100.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	2(.42%)
Forestry around the shelter	f(%)	3(50.0%)	3(50.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	6(1.26%)
Total		101	103	85	51	80	56	476
Settlement Management Strategies for 2100								
Extra Raise Base Foundation	f(%)	13(12.1%)	7(6.5%)	20(18.7%)	9(8.4%)	36(33.6%)	22(20.6%)	107(37.02%)
Unknown	f(%)	48(26.4%)	53(29.1%)	28(15.4%)	27(14.8%)	15(8.2%)	11(6.0%)	182(62.98%)
Total		61	60	48	36	37	23	289

Note: Multiple Response Analysis

Source: Questionnaire Survey, June-October, 2016

7.6.1.5 Adaptation Measures for Land Use in Different Scenarios of Potential Impact of Sea Level Rise

The land use in Bangladesh is generally determined by physiography, climate and land levels.[9] These parameters together make highly complex environment in coastal zone characterized by five main land types related to the depth of seasonal flooding. There are 30 or more agro-ecological zones with differences in soils, climate and hydrology. The areas vary in degrees of risk concerning disastrous floods, drought and cyclones. About 60% of the land is seasonally inundated to a depth of 30 centimeters or more. Land in coastal Bangladesh is used for agriculture, shrimp and fish farming, forestry, salt production, ship-breaking yards, ports, industries, human settlements and wetlands. Land use in the coastal zone is diverse, competitive and often conflicting.

Coastal livelihoods are largely dependent on agricultural crops. The main problems which affect agriculture are physiography, flooding, soil salinity, drain age congestion and irrigation facilities. During wet season agricultural land in the coastal area is limited for cropping because soil salinity is high in the dry season. Salinity intrusion by sea level rise in different scenarios has great impact on land use pattern of coastal Bangladesh. During questionnaire survey it was interviewed with the respondents how they would manage different scenarios regarding sea level rise for land use, multiple response analysis was used as assessing tool. The response of land use for present situation the responses are as 53.62%, 39.31%, 1.03%, 6.03% respectively for crops, shrimp, fruits & vegetables, fresh water fishing. In 2030, for land use management to reduce the impact the sea level rise the responses are soil tolerant crops, shrimp in fresh water as 77.67%, 22.32% respectively. For the land use management of 2050, the responses are Highly Saline tolerant crops, Dam Agriculture, Extensive Shrimp Culture as 66.92%, 31.58%, 1.50% respectively.

The respondents think that 2100 for sea level rise would have huge uncertainty for land use management. The responses were extensive shrimp culture, floating dhap, use of fallow land as 26.91%, 53.36%, 19.73% respectively (table 7.11).

---

[9] H. Brammer, *The Physical Geography of Bangladesh* (Dhaka: The University Press Limited, 2012), 547.

Table 7.11: Adaptation Measures for Land Use in Different Scenarios of Potential Impact of Sea Level Rise

Present Management for Land Use		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Crops	f (%)	62(19.9%)	65(20.9%)	43(13.8%)	40(12.9%)	57 (18.3%)	44(14.1%)	311(53.62%)
Shrimp	f (%)	50(21.9%)	47(20.6%)	47(20.6%)	20(8.8%)	41(18.0%)	23(10.1%)	228(39.31%)
Fruits & Vegetables	f(%)	3(50.0%)	3(50.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	6(1.03%)
Fresh water Fishing	f(%)	4(11.4%)	6(17.1%)	4(11.4%)	4(11.4%)	15(42.9%)	2(5.7%)	35(6.03%)
Total		119	121	94	64	113	69	580
Land Use Management Scenarios for 2030								
Soil tolerant crops	f(%)	66(20.2%)	62(19.0%)	56(17.1%)	33(10.1%)	74(22.6%)	36(11.0%)	327(77.67%)
Shrimp cultivation	f(%)	14(14.9%)	16(17.0%)	6(6.4%)	21(22.3%)	23(24.5%)	14(14.9%)	94(22.32%)
Total		80	78	62	54	97	50	421
Land Use Management Scenarios for 2050								
Highly Saline tolerant crops	f(%)	37(13.9%)	29(10.9%)	36(13.5%)	41(15.4%)	79(29.6%)	45(16.9%)	267(66.92%)
Dam Agriculture	f(%)	39(31.0%)	43(34.1%)	27(21.4%)	11(8.7%)	5(4.0%)	1(0.8%)	126(31.58%)
Extensive Shrimp Culture	f(%)	3(50.0%)	3(50.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	6(1.50%)
Total		79	75	63	52	84	46	399
Land Use Management Scenarios for 2100								
Extensive Shrimp Culture	f (%)	6(10.0%)	3(5.0%)	17(28.3%)	5(8.3%)	11(18.3%)	18(30.0%)	60(26.91%)
Floating Dhap	f (%)	35(29.4%)	40(33.6%)	27(22.7%)	11(9.2%)	5(4.2%)	1(0.8%)	119(53.36%)
Fallow land	f (%)	2(4.5%)	0(0.0%)	11(25.0%)	2(4.5%)	11(25.0%)	18(40.9%)	44(19.73%)
Total		43	43	55	18	27	37	223

Note: Multiple Response Analysis

Source: Questionnaire Survey, June-October, 2016

7.6.1.6 Nonagricultural Activities Adaptation Different Scenarios of Potential Impact of Sea Level Rise

Nonagricultural Activities in rural Bangladesh is defined by different measures. Besides agriculture or simultaneously with agricultural activities a large portion people engage in non-agricultural activities in the coastal area of Bangladesh. The large land owners are elite rural people who are also important part in nonagricultural activities in coastal zone. Day labor or wage labor are classified as distinct class of non-agricultural activities.

Small farmers are the transitional groups between landless and large landowners though they are very close to landless; it is significantly found their involvement in non-agricultural activities. Small fishermen are the single largest groups among the nonagricultural occupations. Fishermen are the single largest groups among the nonagricultural occupations. However, livelihoods in the coastal Bangladesh are broadly clustered into two groups such as natural resource based like agriculture, fishing, aquaculture, extraction of forest resources etc. and human resource based like boat building, net making, fish processing, trading etc.

In the time of questionnaire survey and FGD session conversation with the above group it is found anxiety in the mentioned group regarding sea level rise. Most of the respondents expressed uncertainty for the future event of sea level rise. They were asked how they could manage the different phases of sea level rise.

It reveals after the interview that the responses of present practices are as normal production, normal storage, others as 68.29%, 20.60%, 11.11%. In present position it is found less anxiety and normal activities were given preference. For 2030, situation management, the responses were normal production, safe storage, others as 58.40%, 43.26%, 14.04% respectively. In situation 2050, the preferred answers of the respondents were new production system, new storage strategy, others as 58.40%, 13.18%, 28.42% respectively. In this situation their answers hold anxiety for future occurrence of sea level rise. The respondents are very anxious about the situation of 2100 regarding sea level rise scenarios. A significant number respondent expressed their unbound uncertainty. For the management of the situation their preferred answers were as change in raw material, safe storage**,** unknown as 11.83%, 39.59%, and 48.59% respectively (table 7.12).

Table 7.12: Nonagricultural Activities and Adaptation for Different Scenarios of Potential Impact of Sea Level Rise

Present Management for Nonagricultural Activities		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Normal production	f (%)	63(21.4%)	58(19.7%)	52(17.6%)	29(9.8%)	59(20.0%)	34(11.5%)	295(68.29%)
Normal storage	f (%)	11(12.4%)	8(9.0%)	10(11.2%)	14(15.7%)	31(34.8%)	15(16.9%)	89(20.60%)
Others	f (%)	4(8.3%)	7(14.6%)	1(2.1%)	16(33.3%)	10(20.8%)	10(20.8%)	48(11.11%)
Total		78	73	63	59	100	59	432
Nonagricultural Activities Management Scenarios for 2030								
Normal production	f (%)	20(13.2%)	11(7.2%)	27(17.8%)	19(12.5%)	42(27.6%)	33(21.7%)	152(42.70%)
Safe storage	f (%)	45(29.2%)	47(30.5%)	31(20.1%)	13(8.4%)	17(11.0%)	1(0.6%)	154(43.26%)
Others	f (%)	6(12.0%)	7(14.0%)	1(2.0%)	16(32.0%)	10(20.0%)	10(20.0%)	50(14.04%)
Total		71	65	59	48	69	44	356
Nonagricultural Activities Management Scenarios for 2050								
New Production System	f (%)	48(21.2%)	47(20.8%)	47(20.8%)	20(8.8%)	41(18.1%)	23(10.2%)	226(58.40%)
New Storage Strategy	f (%)	9(17.6%)	6(11.8%)	11(21.6%)	8(15.7%)	13(25.5%)	4(7.8%)	51(13.18%)
Others	f (%)	15(13.6%)	15(13.6%)	6(5.5%)	25(22.7%)	28(25.5%)	21(19.1%)	110(28.42%)
Total		72	68	64	53	82	48	387
Nonagricultural Activities Management for 2100								
Change in Raw material	f (%)	7(15.2%)	3(6.5%)	11(23.9%)	8(17.4%)	13(28.3%)	4(8.7%)	46(11.83%)
Safe Storage	f (%)	40(26.0%)	43(27.9%)	32(20.8%)	16(10.4%)	18(11.7%)	5(3.2%)	154(39.59%)
Unknown	f (%)	27(14.3%)	22(11.6%)	21(11.1%)	29(15.3%)	51(27.0%)	39(20.6%)	189(48.59%)
total		74	68	64	53	82	48	389

Note: Multiple Response Analysis

Source: Questionnaire Survey, June-October, 2016

7.6.1.7 Occupational Adaptation in Different Scenarios of Potential Impact of Sea Level Rise

In coastal area of Bangladesh people are engaged in different occupational activities for their livelihood options. In all the selected study areas, about 50% people catch fish all the year round. April to November is the Ilish season and this time fishermen earn more. Most of the fisher men are engaged in preparation of ‘Shutki’ which is prepared by drying fish in the sunlight. These ‘shutki’ sells to the tourists who come to visit sea beach and to the local people. May to September and November to December is the picking season of paddy (Aman and Ropa). As in this time labor demand is high and day laborer remain so busy in the crop field and they earn more than normal time. From January- April this day laborer engaged in house building and road construction, boating of fisherman, cutting of mud etc. From the mid of September to mid of November, they remain workless in their area. In this time they go to big town to find out job. Van and boat driver earn more during harvest season and people involved in this work remain more or less busy all the year round. On the other side, almost 100% female are housewife. At the same time they involved in vegetable gardening and domestic cattle rearing etc.

In this section respondent were asked about their in general occupational adaptation strategies. For present time occupational activities, their responses were as agricultural activities, and aquaculture or shrimp, NGO or job as 47.79%, 40.82%, and 16.39% respectively. For the situation 2030 their responses were as animal husbandry/poultry, fishery/shrimp, fishery/shrimp, and transportation as 64.53%, 7.94%, 6.59%, and 20.93% respectively. For 2050 situation of sea level rise, their responses were as combined agriculture, local & sea fish, day labor as 85.57%, 12.89%, 1.55% respectively. For 2100 situation they responded as homestead gardening, labor and option for migration as 85.57%, 15.94% and 8.70% respectively. It was found that the main strategies available to poor people with no access to resources are migration, which cannot be classified as adaptation strategies. Sea level rise problem extends the lean period so that more and more people are forced to migrate. Most of the migrants migrate in the nearby divisional or district towns. Livelihood failure and destruction of income sources are the main causes of migration which are revealed in this study (table 7.13).

Table 7.13: Occupational Adaptation in Different Stages of Potential Impact of Sea Level Rise

Present Economic activities Management		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Agriculture	f (%)	57(20.2%)	57(20.2%)	48(17.0%)	36(12.8%)	51(18.1%)	33(11.7%)	282(47.79%)
Aquaculture/ Shrimp	f (%)	59(21.9%)	62(23.0%)	39(14.5%)	28(10.4%)	63(23.4%)	18(6.7%)	269(40.82%)
NGO / job	f (%)	33(30.6%)	40(37.0%)	21(19.4%)	8(7.4%)	5(4.6%)	1(0.9%)	108(16.39%)
Total		149	159	108	72	119	52	659

Occupational Activities Strategies for 2030								
Business	f (%)	59(17.7%)	65(19.5%)	47(14.11%)	44(13.2%)	72(21.6%)	46(13.8%)	333(64.53%)
Animal Husbandry/Poultry	f (%)	10(24.4%)	4(9.8%)	10(24.4%)	5(12.2%)	12(29.3%)	0(0.0%)	41(7.94%)
Aquaculture	f (%)	9(26.5%)	7(20.6%)	4(11.8%)	2(5.9%)	12(35.3%)	0(0.0%)	34(6.59%)
Transportation	f (%)	33(30.6%)	40(37.0%)	21(19.4%)	8(7.4%)	5(4.6%)	1(0.9%)	108(20.93%)
Total		111	116	82	59	101	47	516
Occupational Activities Strategies for 2050								
Combined agriculture	f (%)	68(20.5%)	65(19.6%)	56(16.9%)	33(9.9%)	74(22.3%)	36(10.8%)	332(85.57%)
Local & Sea fish	f (%)	6(12.0%)	7(14.0%)	1(2.0%)	16(32.0%)	10(20.0%)	10(20.0%)	50(12.89%)
Day Labor	f (%)	3(50.0%)	3(50.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	6(1.55%)
Total		77	75	57	49	84	46	388
Occupational Activities Strategies for 2100								
Homestead gardening	f(%)	10(19.2%)	6(11.5%)	11(21.2%)	8(15.4%)	13(25.0%)	4(7.7%)	52(75.36%)
Labor	f(%)	2(18.2%)	0(0.0%)	6(54.5%)	3(27.3%)	0(0.0%)	0(0.0%)	11(15.94%)
Migration	f(%)	3(50.0%)	3(50.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	6(8.70%)
Total		15	9	17	11	13	4	69

Note: Multiple Response Analysis

Source: Questionnaire Survey, June-October, 2016

7.6.2 Institutional Initiatives for Adaptation

To reduce the intensity of SLR impact institutional supports are needed for livelihood security. From household questionnaire survey, it is clear that the institutional helps in adopting adaptation measures in sea level rise condition are found but not significantly. Most of the people use local technologies without any training from GOs and NGOs. Some of the respondents said that they had got training or institutional help in adopting adaptation strategies like early disaster preparedness training, training on life and livelihood development, flood resistant housing, boat modification, domestic cattle rearing and vegetation etc., micro credit, safety net program.[10]

7.6.2.1 Adaptation Measures Taken by Government Organization in Study Areas

From FGD in the study field it is found that different adaptation projects are ongoing and yet to implement by different national GO's to reduce sea level rise impacts. Some of the

[10] FGD, 2016.

adaptation programs implemented by national and local Government institutions are described below-

a) Structural Adaptation Measures

In Structural adaptation measures by GOs Embankment, Putting C.C Block and Sluice Gates are found in the study area. Upazila Parishad, Union Parishad and Water Development Board (WDB) constructs temporary earthen embankment by undertaking different packages. Embankment made by Water Development Board (WDB) is made in Gabura, Lalua and Bharuakhali union. This embankment protects the area from the tidal surge and at the same time works as a road of communication with the adjacent village. Some part of embankment was drowned two times in the river. Though the broken part of embankment was repaired but still that part is in risk.

Water Development Board has undertaken Water sector Management and Improvement Project (WMIP) in order to protect Kuakata sea beach by putting C.C block which is very effective government initiative. Moreover, this project protects are found in all other unions in study area which is most adjacent to the Bay of Bengal and protect area from erosion, saline water intrusion and coastal inundation.[11]

There are number of sluice gates in the rivers and cannels of selected unions to control the water flow during rainy season and saline period which are made by Union parishad and upazila parishad. These sluice gates plays very important role in controlling fresh and saline water. Sluice gates controls entrance of saline water in crop lands and in cannels which are used for fishing.

b) Non-Structural Measures

Non-structural measures are measures not involving physical construction which use knowledge, practice or agreement to reduce disaster risks and impacts, in particular through policies and laws, public awareness raising, training and education. Most the critical situation this system works effectively and it plays very important role in emergency. Government officials in different department provide training to the coastal people for various purposes such as forestry, agriculture, fisheries etc. For example, in coastal zone of Bangladesh forest department plays important roles providing training on

[11] http://bwdb.gov.bd/archive/pdf/364.pdf (accessed 17 November 2016).

forestry and make coastal people aware about the impotance of forest. Mangrove and non-Mangrove Forest plantation is one of the important initiatives to protect coastal area. It reveals from FGD that the Union Parishad, local forest office, WDB involves in tree plantation and gives permission to NGOs for plantation along the side of embankment and in open places. According to local forest officers it was found that the plantation projects are implemented by vulnerable river side. The project along the side of river embankment and in open places to resist sea level rise induced devastating disasters like river erosion, high velocity storm surge.[12]These Mangrove and non-Mangrove forest of forest department not only protects people and resources from disasters but also people of study villages get honey, dry wood and fish in this forest. Forest department also makes wooden watch tower in study areas to provide signal about disasters in advance which helps greatly in early information.

c) Disaster Risk Reduction Activities

Union Parishad Disaster Management Committee (UPDMC), Upazila Disaster Management Committee (UZDMC) provides training on early risk reduction activities about disasters in all study areas. Risk reduction activities include transfer of vulnerable people to safe places like safe shelters from their home, preservation of valuables, drinking water and dry food etc.

d) Measures in Socio-Economic Sectors

Housing, Sanitation, Water and Health related measures fall in socio-economic sectors. Government establishes 'Asrayan program' along the side of the main roads or embankments for the extreme landless poor people. There are also government housing projects in Gabura, Lalua and Bharuakhali union. It is the main asset of coastal families as comparatively secured housing facilities offered here under government supervision. Government also construct tube well and sanitary latrine for these families.

In Gabura and Lalua Union, indigenous (Rakhain Community) peoples who lived outside the embankment now lives in a government provided housing. The government also installed tube-well and latrines for the community. During FGD, they have identified that water and sanitation as one of the major problem of their community. They also said that

[12] *www.bdresearch.org/home/attachments/article/nArt/Mangrove.pdf* (accessed 21 November 2016).

the community latrine gets flooded during high tide and is now very unhygienic. Vulnerable people of research villages especially women and children are suffering from malnutrition, cold/fever, dysentery/ diarrhea, skin diseases, asthma, jaundice due to high level salinity which will be accelerated by sea level rise induced disasters. No mentionable government program on climate-sensitive diseases related adaptation measures are found in the study areas. From field survey, it was found that health sector of study areas is the most neglected as no significant government intervention exists in these areas.

d) Adaptation for Food Security

Upazila Agriculture Office, Sub Assistant Agriculture Officer (Union Block Supervisor office) involves in free seed distribution, skill enhancement through training of community people and gives them technical support for homestead vegetable gardening. People can ensure their food security through livestock and homestead vegetable gardening. Upazila Livestock Office gives livestock to local poor people free of cost and provides training to community people, training to develop knowledge on immunization and rearing technology of livestock. People can earn by selling this vegetables and livestock after meeting their household demand.

e) Adaptation in Agriculture and Fisheries

Due to change in rainfall pattern, seasonality and sea level raise, study villages is now facing the problem of salinity in field. Lack of awareness, broken sluice gates and embankments, shrimp culture, and having not enough capacity of irrigation made the crop fields more salty during the winter and some part of summer season. Upazila Agriculture Office, Union Block Supervisor Office provides training to the farmers on updated and scientific farming method, seed collection and provides technical support to the farmers.

Local Fisheries and livestock office is responsible for preserving fisheries resources, creating employment opportunities for rural poor people, exporting fish and fishery products, managing water bodies and research in fisheries and livestock development. All the fish collected from Bay of Bengal, rivers and channels. Fishery products such as 'Shutki (dry fish)', fish feed etc. produced by local fishermen of adjacent all villages are collected and marketed locally and internationally with the help of close monitoring and supervision of local office of Fisheries and livestock.

7.6.2.2 NGOs Involvement in Adaptation Sector

The NGO's of study area have taken some projects in the six selected unions to reduce sea level rise implications on socio-economic sectors and also to minimize physical exposure to sea level rise induced disasters of the area. Disaster preparedness and risk reduction skill development on community basis, awareness raising, motivation, skill development training of women and farmer, micro credit, emergency relief help etc. are the ongoing programs and activities of different NGO's that are working in six research areas. The list of NGOs that are working in research unions and their activities in sea level rise adaptation sector are presented in appendix-c.

Adaptation Programs by NGOs in Study Areas

During FGDs and household questionnaire survey, people mentioned about few NGOs who taught them effective adaptation strategies. Key Informants Interview (KII) in different organizations revealed that different NGOs are involved in adaptation techniques among local people. Mainly these NGOs are actively involved in popularizing adaptation strategies in the areas.

a) Infrastructural Adaptation Measures

Community House, Flood Resistant Housing are found as infrastructural measures in the study area. Building of several community houses are a unique idea for research and discuss among the local people to adapt with the SLR impacts introduced by Disaster Risk Reduction (DRR) project of Action Aid in study area. There are several community houses which are doing research work. These housing was built with the objective of using it as a multipurpose community house. These houses are built at the available safe places provided by community people's demand.

It has been observed that the people do not want to leave their household belongings behind during any disaster and that is why they always start for the shelter at the eleventh hour when the force of the disasters tends to damage their house and put their lives into risks. Now, considering the future scenario of SLR where climate change scientist predicting that there will be more climatic disasters with higher intensity in the coastal region of Bangladesh. Keeping that in mind, the DRR project of Action Aid wanted in do something to reduce such risks of disasters.

Weak structure easily collapses during high wind, cyclones and storm surges. That's why houses were modified and upgraded for safety by Participatory design and construction, Synthesis of technical knowledge and local knowledge and Local materials used with strong integrity. Different NGO has facilitated the construction of houses in these six selected unions for the poorest people to build their resilience to flooding in terms of protecting human rights, securing livelihood, increasing mobility etc. These homesteads have been constructed in six unions to reduce the vulnerability of the community from every year inundation or to protect the households from flood submerging. It is expected that the options will also provide more space for homestead gardening, cattle shelter and play ground of the children.

b) Sanitation, Water Security Measures

Different NGOs that are working in research areas distributing latrines among poor people of study villages to reduce their exposures to health related hazards. The latrine is especially designed so that it would be safe during the high tide time. The latrine would also be useable even after cyclone as the base of the latrine has been designed considering future possible disasters (sea level rise, cyclones and salinity).

There is scarcity of pure drinking water in all research unions. Here about 51.7% drink tube well water and about 48.2% households drink water from other sources i.e. pond, river and cannel water, harvested rain water, filtered water provided by NGOs etc.

c) Project Oriented Measures

Distribution of tube well, pond excavation and raising boundary of ponds are included in different projects. The community with the support from different projects of NGOs has installed tube wells. NGO also distributes water purification tablet and Fitkiri among local people free of cost to reduce their exposures to lack of safe drinking water.

One major problem in these unions is saline water percolation from the surrounding sea and rivers to sweet water reservoir ponds. Different NGOs excavate and raise boundary of ponds for sweet water reservation for drinking purpose during disaster period but ponds excavated by the NGOs do not work out properly due to this saline water percolation through soil and high velocity storm tide.

d) Health and Food Security Measures

NGOs have some projects on health care at study areas, but it is not climate related. Community clinics mainly provide emergency medical services in the study areas. Facilities of the Community clinics are not improved and there is lack of medicine and trained health worker. Health workers and family planning workers don't perform their job properly. They have no plan or idea how they will face climate change occurring catastrophic situation. There is no climate-sensitive disease surveillance and control cell. Adaptation measures taken in health sector by NGOs are very negligible in study areas.

Homestead vegetable gardening is one of the activities provided to supply better nutrition for the family. It is expected that the initiatives will protect the HHs from micro-nutrient malnutrition round the year especially in the lean seasons and they can earn money by selling that. Different NGO's therefore has supported households with seed and training. They provided with skill training on seed preparation and preservation, homestead gardening, bed preparation, bamboo tree plantation and preservation.

e) Occupational Adaptation Measures

Vegetable marketing, livestock related training etc. are found in the study area. Different NGO's has supported households with seed and training for homestead vegetable gardening so that people can earn money by selling extra vegetables after meeting their household demand.

Vulnerable women have been facilitated to have goats each for generating income by different NGO projects, and that in turn gives the opportunity to open small businesses, send children to school and generally live better lives. Training on goat rearing was also a need identified by the community and arranged accordingly in four villages.

Different NGO provides skill training on handicrafts and create market linkages for marketing of these products locally and nationally. Through this handicrafts production and marketing, local people can earn money.

a) Adaptation Measures in Agricultural and Fisheries Sector

The DRR project of Action Aid is now working on BORO cultivation. The project supported the farmers with seeds, pump machine for irrigation, fuel, fertilizer and other technical support. It is found in the study that the farmers agreed with the proposal of providing 20% of his/her production to the community which will be preserved and used as mother seed for BORO cultivation in future (FGD, 2016).

Different NGO's working to promote fisheries aquaculture for promotion of salt tolerant species, rehabilitation of degraded habitat and maintenance of fish migratory routes and improve design and construction quality of fishing boat having capacity to safe return to shore during bad weather condition.

7.6.2.3 Community Based Adaptation Strategies

Community based adaptation strategies are found in coastal region of Bangladesh. They are in the form of structural and non-structural measures.

a) Structural Measures

Embankment, Pond Excavation, Raising the Boundary of Pond etc. are included in structural measures of adaptation. Traditionally, the coastal people dig holes inside their houses and cover their valuables with soil. The approach of mixing local and scientific or technical knowledge uses in many other adaptation measures, such as designing sanitary latrines considering inundation period and introducing appropriate cultivation methods in saline land. The local people's team come up with is to build a collective bunker under the team house where villagers can store their belongings safely while they are in the safety of the cyclone shelters.

People of study areas construct and repair earthen embankment in different places where they think that is necessary. They involve their physical labor in this construction and repairing process. This effort of community people protects their settlement and land from river erosion, saline water intrusion in their crop field and longtime coastal inundation.

There are some CBOs in six research unions which are involved in fish cultivation at community level ponds and re-excavation of cannels for irrigation. These excavated ponds used also as a reservoir of sweet water during disaster period.

c) Nonstructural Adaptation Measures

Sluice Gate Maintenance, Tree Plantation etc. are found in the study area as nonstructural adaptation measures. Sluice gate maintenance is a good example of community level effort in research villages. Community people closely monitor the sluice gate opening and closing during winter and summer season because saline water enters into the adjacent channels and crop fields through these sluice gates. This saline water severely hampers agricultural production from their field. Some local elite and dishonest people trying to get lease of sluice gate adjacent cannels for shrimp culture and they keep sluice gate open during saline period. Due to leasing out of these channels, local residents cannot use the cannel water for irrigation and fishing. In order to stop this illegal practice of local elites, community people can able to cancel the lease agreement with the help of union parishad. This community effort protected land from the detrimental effect of SLR induced disasters especially saline intrusion (FGD, 2016).

To protect coastal area from the effect of climatic adversity trees play a vital rule. Some NGOs are working in the coastal area for tree plantation. Embankment tree plantation is one of their important projects. “Patuakali Mohila Unnayan Samity” is a CBO at Kalapara. It has a project named “Coastal Embankment Rehabilitation Project”, funded by DANIDA. Coastal afforestation is the main activity of this CBO (FGD, 2016).

7.7 Statistical Assessment of Coping and mitigation for SLR

From questionnaire survey it was found that income level of household of the study area was diverse. Correlation between income level and different coping strategy in terms of sea level rise was assessed. Considering the income level different coping capacities were correlated in the study area (table 7.14).

Table 7.14: Correlation between Income Level and SLR Coping Strategies

		Income Level	Agricultural Coping strategy	Salinity Coping strategy	Settlement Coping strategy	Occupational Coping strategy	Land use Coping strategy
Income Level	Pearson Correlation	1	.694**	.839**	.889**	.874**	.878**
	Sig. (2-tailed)		.000	.000	.000	.000	.000
	N	380	380	380	380	380	380
Agricultural Coping strategy	Pearson Correlation	.694**	1	.537**	.540**	.508**	.460**
	Sig. (2-tailed)	.000		.000	.000	.000	.000
	N	380	380	380	380	380	380
Salinity Coping strategy	Pearson Correlation	.839**	.537**	1	.904**	.916**	.880**
	Sig. (2-tailed)	.000	.000		.000	.000	.000
	N	380	380	380	380	380	380
Settlement Coping strategy	Pearson Correlation	.889**	.540**	.904**	1	.932**	.942**
	Sig. (2-tailed)		.000	.000		.000	.000
	N	380	380	380	380	380	380
Occupational Coping strategy	Pearson Correlation	.874**	.508**	.916**	.932**	1	.946**
	Sig. (2-tailed)		.000	.000	.000		.000
	N	380	380	380	380	380	380
Land use Coping strategy	Pearson Correlation	.878**	.460**	.880**	.942**	.946**	1
	Sig. (2-tailed)		.000	.000	.000	.000	
	N	380	380	380	380	380	380

Note: **. Correlation is significant at the 0.01 level (2-tailed).

Source: Field Questionnaire Survey, 2016.

In the present study it was found that dwelling duration of the respondents were different in study area of coastal zone. Correlation between dwelling duration and and different coping capacity in terms of sea level rise was assessed and it was clear that there was clear correlation among them in the study area (table 7.15).

Table 7.15: Dwelling Period and SLR Coping Strategies

		Dwelling Period	Agricultural Coping strategy	Salinity Coping strategy	Settlement Coping strategy	Occupational Coping strategy	Land use Coping strategy
Dwelling Period	Pearson Correlation	1	.547**	.849**	.905**	.905**	.926**
	Sig. (2-tailed)		.000	.000	.000	.000	.000
	N	380	380	380	380	380	380
Agricultural Coping strategy	Pearson Correlation	.547**	1	.537**	.540**	.508**	.460**
	Sig. (2-tailed)	.000		.000	.000	.000	.000
	N	380	380	380	380	380	380
Salinity Coping strategy	Pearson Correlation	.849**	.537**	1	.904**	.916**	.880**
	Sig. (2-tailed)	.000	.000		.000	.000	.000
	N	380	380	380	380	380	380
Settlement Coping strategy	Pearson Correlation	.905**	.540**	.904**	1	.932**	.942**
	Sig. (2-tailed)		.000	.000		.000	.000
	N	380	380	380	380	380	380
Occupational Coping strategy	Pearson Correlation	.905**	.508**	.916**	.932**	1	.946**
	Sig. (2-tailed)		.000	.000	.000		.000
	N	380	380	380	380	380	380
Land use Coping strategy	Pearson Correlation	.926**	.460**	.880**	.942**	.946**	1
	Sig. (2-tailed)		.000	.000	.000	.000	
	N	380	380	380	380	380	380

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Field Questionnaire Survey, 2016.

During the field survey it was found the there were different occupational group in the study area. Different coping strategies in terms of occupational group were correlated (table 7.16).

Table 7.16: Correlation between Occupation and SLR Coping Strategies

		Occupation Type	Agricultural Coping strategy	Salinity Coping strategy	Settlement Coping strategy	Occupational Coping strategy	Land use Coping strategy
Occupation Type	Pearson Correlation	1	.258**	.775**	.851**	.831**	.919**
	Sig. (2-tailed)		.000	.000	.000	.000	.000
	N	380	380	380	380	380	380
Agricultural Coping strategy	Pearson Correlation	.258**	1	.537**	.540**	.508**	.460**
	Sig. (2-tailed)	.000		.000	.000	.000	.000
	N	380	380	380	380	380	380
Salinity Coping strategy	Pearson Correlation	.775**	.537**	1	.904**	.916**	.880**
	Sig. (2-tailed)	.000	.000		.000	.000	.000
	N	380	380	380	380	380	380
Settlement Coping strategy	Pearson Correlation	.851**	.540**	.904**	1	.932**	.942**
	Sig. (2-tailed)		.000	.000		.000	.000
	N	380	380	380	380	380	380
Occupational Coping strategy	Pearson Correlation	.831**	.508**	.916**	.932**	1	.946**
	Sig. (2-tailed)		.000	.000	.000		.000
	N	380	380	380	380	380	380
Land use Coping strategy	Pearson Correlation	.919**	.460**	.880**	.942**	.946**	1
	Sig. (2-tailed)		.000	.000	.000	.000	
	N	380	380	380	380	380	380

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Field Questionnaire Survey, 2016.

Education level is important indicator to find the right decision to combat against any adversity. In the present study a consistency about the relation was found among the education level and different SLR coping strategy (table 7.17).

Table 7.17: Correlation between Education Level and SLR Coping Strategy

		Education Level	Agricultural Coping strategy	Salinity Coping strategy	Settlement Coping strategy	Occupational Coping strategy	Land use Coping strategy
Education Level	Pearson Correlation	1	.280**	.874**	.844**	.874**	.912**
	Sig. (2-tailed)		.000	.000	.000	.000	.000
	N	380	380	380	380	380	380
Agricultural Coping strategy	Pearson Correlation	.280**	1	.378**	.377**	.347**	.305**
	Sig. (2-tailed)	.000		.000	.000	.000	.000
	N	380	380	380	380	380	380
Salinity Coping strategy	Pearson Correlation	.874**	.378**	1	.928**	.892**	.906**
	Sig. (2-tailed)	.000	.000		.000	.000	.000
	N	380	380	380	380	380	380
Settlement Coping strategy	Pearson Correlation	.844**	.377**	.928**	1	.930**	.894**
	Sig. (2-tailed)		.000	.000		.000	.000
	N	380	380	380	380	380	380
Occupational Coping strategy	Pearson Correlation	.874**	.347**	.892**	.930**	1	.924**
	Sig. (2-tailed)		.000	.000	.000		.000
	N	380	380	380	380	380	380
Land use Coping strategy	Pearson Correlation	.912*	.305*	.906*	.894*	.924*	1
	Sig. (2-tailed)		.000	.000	.000	.000	
	N	380	380	380	380	380	380

**. Correlation is significant at the 0.01 level (2-tailed).

7.8 Challenges for Coping and Adaptation

Scientific advancements already have established an evident connection among climate change induced accelerated sea level rise (SLR) and various hydro-metrological disastrous events. The accelerated SLR would probably increase the frequency and magnitude of coastal flooding, salinity intrusion, cyclonic storm and surge, and coastal erosion.

The respondents in the study area are familiar with many of these disastrous events, in the changing scenarios of future climate and SLR. Their known pattern of such disastrous events would appear very differently than now.

Coastal flooding and salinity intrusion encroach much larger areas in coastal area. More horrific thing is such flooding is perpetual. Once an area goes under flood water it would never return to its earlier stage. Peoples are familiar with seasonal inundation of their farmlands, lowlands, water-bodies which return to their original states after some times of inundation. However, peoples are not familiar with the perpetual nature of inundation that is more likely in the event of accelerated SLR. This is a big challenge for future livelihood security.

Most respondents are familiar with seasonal nature of intrusion of saline water in the soil, sub-soil water table and in surface water bodies. Although such salinity reaches its pick during the dry season and makes the land unsuitable for most winter-crops cultivation, the salinity level starts to go back as soon as the rainy season starts. However, in the changing scenario of SLR, such salinity would be acute which may not only jeopardize year round productivity of crops most importantly that may create havoc due to acute scarcity of fresh water for domestic and consumptive uses. How people might cope and adapt with this new circumstance is really a challenge for future.

As people have been coping and adapting with various disastrous situations often successfully by employing various techniques that are grounded on their indigenous knowledge, local culture and tradition, they seem strong caring about the future vulnerabilities. Significant portion of respondent think that their current coping and adaptation strategies are enough to overcome such hindrances. In response to question whether they feel the need for updating current coping and adapting strategies for agriculture activities, fishing related activities a number of respondents indicated that they do not really need any external training for most adjustment related to agricultural activities. Likewise, for the activities that are related to secure homestead construction and maintenance.

Although a great majority of the respondents have accrued experience of coping and adaptation against various impacts of different natural hazards, yet their confidence about coping and adaptation against future vulnerability without upgrading current practice of coping and adaptation really raised some concerns.

First, whether they are really aware about the most probable impacts of SLR and its associated events on their lives, property and livelihood avenues.

Second, whether they are overestimating their adaptation efficacy. In the study it is found from FGD that probably they are not well aware about the differential nature of threats of future events. It is partly because as the SLR induced events are new and very distant phenomenon which they have very limited or no understanding. Therefore, they consider the future threats as the same threat they have encountered in the past.

Therefore, it is concluded that if the respondents were much aware about the various aspects of climate change induced SLR vulnerabilities they would probably more eager to update their current coping and adaptive measures.

7.9 Chapter Summary

A wide range of adaptation strategies have been presented in this section for Sea Level Rise adaptation strategy for coastal zone of Bangladesh. This strategy focused on adaptive management to prepare for the impacts of sea level rise in order to safeguard the community, environment and economy from likely risks. The Strategy should ideally be produced in close consultation with all stakeholders including the local community and provide specific local plans to increase the communities resilience to sea level rise. As most of the population of the coastal communities of Bangladesh are fishermen and farmers, the adaptation options should be emphasized on these two sectors to overcome the problems of the anticipated issues. A decision cannot fully to adapt or respond to the pressure of sea level rise risk but can reduce result in the community being exposed to unacceptable levels of risk. However, a precautionary response may be appropriate when decisions are being made relating to long life strategic infrastructure or long term planning. Present chapter finds the following measures generally preferred by the coastal people.

1) The coastal area of Bangladesh is prone to multiple natural hazards which include coastal flooding, cyclonic storm, salinity intrusion, prolong rainfall etc. It is revealed in the study that the respondents have been coping and adapting against various hydro-meteorological disastrous events time and again.

2) In general the respondents of the study area are familiar with the probable timing of occurrence of the disastrous events. But they strongly rely on both institutional and non-institutional sources for information. Among the sources radio appears to be the most credible source. Radio is widely used in the area as it is easy to operate and not very expensive. It is also revealed that higher age, higher duration of stay in the coastal area, nature of occupation (e.g. fishing community) and past adaptive behavior against salinity are also associated with higher level of climate awareness.

3) For coping and adapting with livelihood insecurity for future scenarios of SLR various occupational groups employ various coping and adapting measures. Agriculture based occupation group often employs coping and adaptive measures regarding rice varieties, replanting, change in cropping time, emphasis on non-crops agriculture, and other method of soil and irrigation management which are revealed in the study.

4) Fisher group employ various coping and adaptation strategies for fishing in difficult situations. This group of respondents faces critical livelihood challenges during gusty wind, prolong rainfall, low-pressure system, cyclone and wave surge when the bay become hostile. To cope and adapt with such situation in any future situation they avoid deep sea fishing, limit fishing in inland water bodies, river-estuaries, use good information system, use improved fishing gear and net.

5) Other occupational group such as day laborer, van, boat driver earn generally in harvesting season more and people involved in this work remain more or less busy all the year round. Although SLR is new phenomena to them but there are some anxieties in them. It is found from their statement in the case of existence as dwelling place goes under water due to SLR they would leave the place for livelihood security to nearby cities. On the other side, the female respondents who are engaged in vegetable gardening, domestic cattle rearing etc. have uncertainty for adaptation strategies.

6) It reveals in the study that people in the coastal areas have been coping and adapting with various hydro-meteorological disastrous for a long period of time. A significant number of the respondents think that they or their future generation would probably evacuate the current place of living and relocate further inland if the vulnerability of SLR exceeds their coping range. For example, by the year 2050-75 if their farmlands go permanently half-knee height (20-25 cm) below saline water a significant part (30%) of the respondents would prefer migration. Moreover, it is found huge uncertainty regarding livelihood security by the year 2100 in the case of 1meter rise of sea level.

7) It further reveals in the study that a significant portion of the respondents believe that enhancement of adaptive capacity measures will be effective to decrease the likely trend of forced migration and mitigate uncertainty anxiety of coastal people.

Accordingly, they have identified initiatives like special safety-net for coastal communities and community food security program as top priority initiatives in this regards. In fact, implementation of these two measures along with initiative for coastal resource based adaptive livelihood will strengthen the accurate foundation of adaptive capacity of the probable climate migrants.

8) Finding reveals that age, education, income etc. likewise exposure potential of disastrous events in the coastal areas, nature of occupation, information sources, past adaptive behavior against flood and scarcity of water of the study area are the main indicators for different adaptive measures in different scenarios of potential impact of sea level rise.

Chapter Eight
Institutional Mechanism for SLR Induced Disaster Mitigation and Livelihood Security

8.1 Introduction

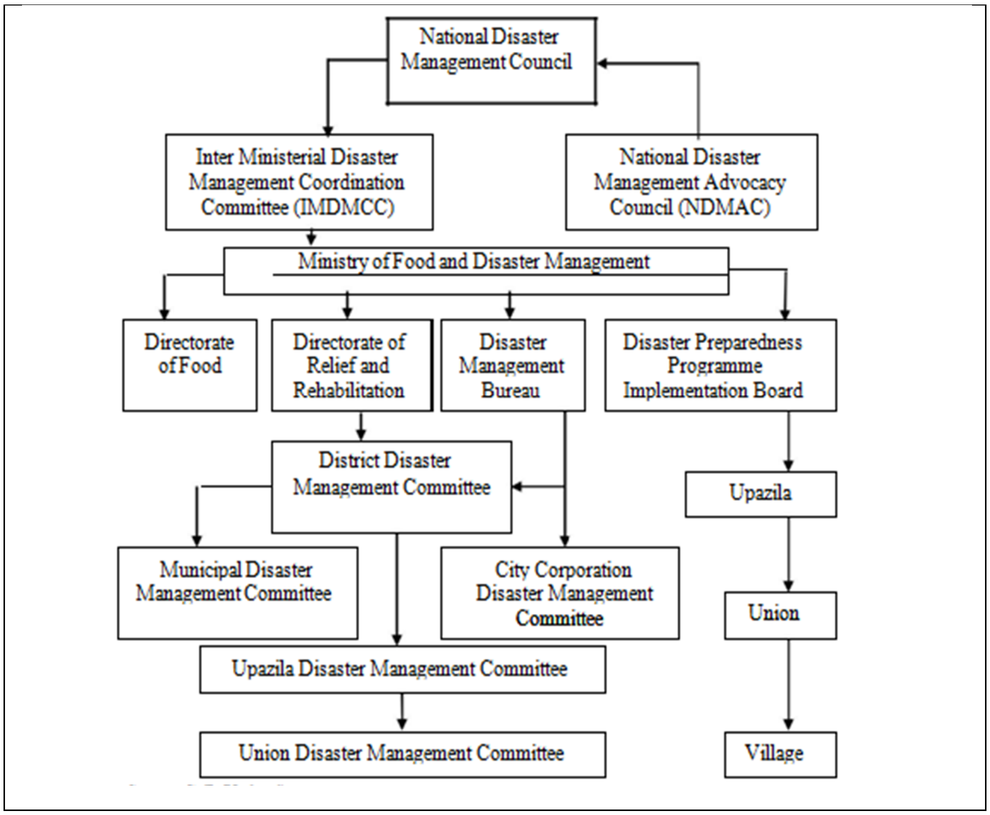
Discussion of previous chapter investigated various adaptation strategies adopted by households in response to impact of SLR in study areas. Various institutions work as a social strengthening means to bond different stakeholders and intervene access to various livelihood capitals to adopt positive or negative adaptive measures from livelihood security point of view. It is identified in the present study that different organizations are directly or indirectly involved in disaster mitigation in Bangladesh which has significant impact on coping strategy and post disaster livelihood security. Such organizations are government departments, non-government organizations, international organizations and donor agencies. In this chapter various disaster management issues, involved different organizational activities with special reference to SLR impact in Bangladesh are reviewed and role of different organizations at village level for SLR induced disaster mitigation and securing livelihood are examined.

Based on household survey, activities of different local organizations are assessed considering the respondents' perception about the support services to be provided in future periods for better adoption of adaptation strategies and achieving sea level rise impacted livelihood security.

8.2 CC Induced Disaster Risk Reduction in Bangladesh: A Brief Overview on the Perspective of Household Coping, Adaptation and Livelihood Security

Bangladesh has a reputable disaster management institutional system, in which the apex body is National Disaster Management Council (NDMC). Inter-Ministerial Disaster Management Coordination Committee is the coordinating body among different ministries. In addition to NMDC district level to sub-district and union level disaster management committees work under MoFDM. Disaster Preparedness Program Implementation Board under the MoFDM works at sub-district, union and village level for dealing with rehabilitation and livelihood security related issues. In addition to the government bodies several Non-government Organizations (NGOs) work mostly at field level for awareness building, relief, rehabilitation and rebuilding livelihoods. NGOs activities are also coordinated by MoFDM. [1]

Figure 8.1: Comprehensive Disaster Management Institutional Framework in Bangladesh



Source: National Plan for Disaster Management, Government of the People's Republic of Bangladesh, Disaster Management Bureau, Disaster Management & Relief Division, April 2010, available at http://modmr.portal.gov.bd/sites/default/ files/files/modmr. portal. gov.bd/ publications/b8fd567a_ 3672_416a_88ad_373dea1a2518/Nataional _Plan_for_Disaster__2010_2015__Final_Version-.pdf (Accessed 12 October 2016).

According to the risk reduction strategic priorities, Bangladesh government's declared goal is to reduce the risk of poor and disadvantaged people from the adverse impacts of natural, environmental and manmade hazards up to a convenient and satisfactory level.

In this regard, the major achievements of Bangladesh government are National Disaster Management Framework, Corporate Plan of Ministry of Food and Disaster Management, Standing Orders on Disasters (SOD), and Comprehensive Disaster Management Programme (CDMP). The corporate plan is an action oriented policy framework to

[1] Mizan R Khan and M. Ashiqur Rahman, "Partnership Approach to Disaster Management in Bangladesh: A Critical Policy Assessment," *Natural Hazards* 41, no. 2 (2007): 361.

reduce disaster risk during 2005-2009. To reduce vulnerability of people to various disasters, it works as a key management tools for guiding and prioritizing government's activities on disaster management. Similarly, Standing Orders on Disasters (SOD) is recognized step for disaster management in Bangladesh. SOD clearly defines the roles and responsibilities of various ministries, divisions, departments, involved organizations and various committees at different levels for disaster risk reduction, emergency management, rehabilitation and rebuilding livelihoods. On the other hand, comprehensive disaster management programme (CDMP) is a long term programme of MoFDM with multi-agency participation with an objective of enhancing government's capability of disaster management to reduce undesirable risks and assist recovery, rehabilitation and restoration of livelihoods of victims.

8.3 Information Regarding SLR Threat at Community Level: Issues of Enhancing Adaptive Capacity

Bangladesh Meteorological Department (BMD) is the main responsible authority to handle for giving the information of SLR in Bangladesh. It prepares SLR information and provides to the public media for open broadcasting. Climate change cell (CCC) is responsible for the dissemination of SLR warnings at local level to the coastal villagers. The institution is responsible for weather forecasting and issuing related warnings to sea and river ports, and public as well. It also provides disaster warning message to different other users including NGOs, relief and rehabilitation authorities and local level government officials for assisting vulnerable people to adopt precautionary measures. The organization also prepares special weather bulletins instantaneously after the formation of any atmospheric hazard in the Bay of Bengal.[2]

Climate Change Cell of Department of Environment has engaged IWM to carry out the impact assessment of climate change (causing increased rainfall and sea level rise) on monsoon flooding based on the recommendations of the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC). The Climate Change Cell of the Department of Environment (DOE) initiated the steps for spreading the

[2] K. M. M. H. Chowdhury, Cyclone Preparedness and Management in Bangladesh. In: BPATC (ed) *Improvement of Early Warning System and Responses in Bangladesh Towards Total Disaster Risk Management Approach,* (Dhaka: BPATC, 2000), 117.

information of SLR threat at Community Level. It was conducted by the Centre for Environmental and Geographical Services (CEGIS**).**

8.4 Key Units of the Country Involved in Sea Level Rise Adaptation

To make the coastal people more resilient in various climatic events different ministries and departments are involved. It is found in field survey talking with the personnel of upazilla administration that these ministries and department generally take necessary program for livelihood security of coastal people. These are as below

8.4.1 Ministry of Environment and Forests

The Ministry of Environment and Forests is the focal ministry for all work on climate change. It is in charge of mainstreaming climate change into national development planning and for implementation of the national Bangladesh Climate Change Strategy and Action Plan (BCCSAP). Recently, the government has opened a new Centre for Climate Change. The main responsibilities of this centre are to manage all climate change-related policies.[3]

8.4.2 Ministry of Agriculture

As climate change induced sea level rise is severely affecting agricultural production in Bangladesh, the Ministry of Agriculture is another key player in relation to SLR adaptation. It is in charge of developing and promoting new agricultural technologies to boost agricultural productivity through different research agencies, including the Bangladesh Agricultural Research Council, Bangladesh Agricultural Research Institute, Bangladesh Rice Research Institute and Soil Resource Development Institute. The ministry provides extension services through the Department of Agricultural Extension to increase productivity and technology transfer.[4]

8.4.3 Ministry of Water Resources

Through the Bangladesh Water Development Board, this ministry is handling a variety of water-related issues such as flood control and flood forecasting, irrigation schemes and management of underground and surface water resources to boost agriculture and

[3] M. S. Iftekhar and M. R. Islam, "Managing Mangroves in Bangladesh: A Strategy Analysis," *Journal of Coastal Conservation* 10, no. 1 (2004): 141.

[4] MD Masud Karim, "Arsenic in Groundwater and Health Problems in Bangladesh," *Water Research* 34, no. 1 (2000): 305.

fisheries. Furthermore, the ministry is responsible for coastline protection, soil conservation and prevention of salinity intrusion.

8.4.4 Ministry of Local Government, Rural Development and Cooperatives (LGRD)

Under LGRD ministry, the Local Government Engineering Department is in charge of development and management of local infrastructure for increasing production and creating employment; developing, maintaining and managing transport, trading and small-scale water resources infrastructure at local level. The Department of Public Health and Engineering is also under this ministry. This department is responsible for drinking water and sanitation facilities.

8.4.5 Ministry of Food and Disaster Management

Through the Disaster Management Bureau, this ministry is responsible for executing and coordinating all activities in relation to disaster management action plans from national to local level. This includes disaster preparedness, local-level disaster action and raising awareness about these. This ministry has a pivotal rule to make planning to combat future adversity of SLR.

8.4.6 Ministry of Fisheries and Livestock

This ministry is responsible for preserving fisheries resources, creating employment opportunities for rural poor people, exporting fish and fishery products; managing water bodies and research in fisheries and livestock development.[5]

8.4.7 Local Government Institutions Involved in Sea Level Rise Adaptation in Study Areas

There are a lot of debates regarding the activities of local government institutions on the national and international levels for the co-operation of adaptation strategies but the total process is an inherently local process. For adaptation processes to succeed, much depends on the capacity and will of local government and public service institutions to act on climate change. Here local institutions include local government (e.g. union parishad, upazila parishad) and public service institutions (e.g. agriculture extension services,

[5] Nesar Ahmed, Harvey Demaine and James F. Muir, "Freshwater Prawn Farming in Bangladesh: History, Present Status and Future Prospects," *Aquaculture Research* 39, no. 8 (2008): 806.

livestock offices, etc.). Talking with the local people in the field study period it was found that in all the six research unions of the study area, local government institutions play a very significant role in adaptation to sea level rise.

8.5 Assistance for Sea Level Rise Risk Reduction, Coping, Adaptation on Livelihood Security: A Discussion Based on Household Survey

A brief overview of disaster management institutions and their activities for disaster risk reduction at macro scale has been discussed in the previous section of this study. According to the guideline provided by CCC this section of the present study provides a brief overview of potential sea level rise impact reduction activities undertaken by different organizations at village level, and assesses the extent of effectiveness of such activities based on respondents' perception about adoption of coping strategies and sea level rise disaster related livelihood security.

8.5.1 Community Awareness Programs and Preparedness Measures in Study Unions

Village level disaster risk reduction activities of different local organizations are assessed based on their activities at normal times, disaster stage and rehabilitation stage. Normal time and pre-disaster stage activities include arranging training, publicizing different warnings, preparing village disaster vulnerability maps, preparedness training for pisciculturist and fishermen, encouraging people to listen regular weather information, communicate with safer places, mobilization practices on various disaster related matters, and ensuring protection of drinking water sources.

The present study finds that very few (32.40%) respondents had participated on the community based awareness creation programs. More number of respondents in Munshigonj (45.8%) and Khurushkul (42.9%) had participated in community based awareness programs and comparatively less in Gabura (23.6%) and Lalua (24.6%) and Nilgonj (16.3%). On the other hand, majority of the respondents in study unions had not participated on such programs. Significant difference exists among the villages in terms of the availability of such programs, where Gabura and Lalua are more disadvantageous position than Inland union (table 8.1).

It is mentionable that even though Bangladesh government has given special priority to the remote Islands and char lands, institutional assistances related to preparedness and awareness building but has not reached the remote locations accordingly. On the other hand, respondents received assistances related to awareness campaign were mostly provided after the occurrence of disastrous event by different NGOs. All the study areas are well connected through road networks to the Thana headquarters. Therefore, many NGOs are working in the study areas. On the other hand, remote areas are out of the service of majority of the NGOs. Such finding is consistent with some previous studies that many NGOs operate their activities in coastal zo ne but few of them are working in the remote areas.[6] Similarly most of the NGOs are involved in micro-credit programs and main beneficiaries of such micro-credit programs are located in the 'interior coast'.

Table 8.1: Organizational Assistances for Community Based Awareness Program

Organizational Assistance for Sea Level Rise		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Yes	n	33	17	14	8	36	15	123
	%	45.8%	23.6%	24.6%	16.3%	42.9%	32.6%	32.4%
No	n	39	55	43	41	48	31	257
	%	54.2%	76.4%	75.4%	83.7%	57.1%	67.4%	67.6%
Pearson Chi-Square	Value= 20.055, df=5, p =0 .001							

Source: Questionnaire Survey, June-October, 2016

From FGD and questionnaire survey the present study also finds that after the occurrence of severe climatic disastrous events few NGOs have incorporated disaster risk reduction as additional activity to their normal work such as micro-credit and other development activities. Major organizations involved in awareness campaign in study area are BRDB, PRASHIKA, CARE AND CRITAS (table 8.2). BRDB had provided some training regarding disaster to its volunteers. Activities of this organization were found in the coastal area.

However, each of the volunteers usually undertakes their activity to the respective areas. As mentioned earlier that study areas are located in seashore with high level of vulnerability to hydro-meteorological event. Hence, it is utmost important to expand and execute BRDB's activities to such remote place. Therefore, such issues need to be taken care of with urgent basis by giving additional priority to the remote coastal areas.

Likewise, PRASHIKA is working in Bangladesh for long time in the field of education, health, socio-economic development. At present this organization included disaster risk

[6] Mohiuddin Ahmad and Atiq Rahman, "The Stimulating Role of Ngos in Bangladesh," *Climate of Coastal Cooperation. Coastal & Marine Union, The Netherlands* (2011): 62.

reduction activities in their core developmental activities. Similarly, CARE is also an NGO focuses mainly the risk reduction program.

After the occurrence of catastrophic event this organization had provided awareness campaign among the coastal villagers focusing mainly the women. It reveals that higher number of respondents had participated in awareness campaign by BRDB in the union of Munshigonj (33 people) and few in Khurushkul Union (36 people). Major focusing area of this training program was safer evacuation following any climatic warnings (table 8.2).

It is found in the field study that some NGOs are not likely to work in most exposed coastal zones. As a result people of these areas face recurrent vulnerabilities to multiple coastal hazards and are underprivileged for basic services due to isolation of such places and remain inactive for precautionary coping measures to potential impact of disaster. Such finding also revel the lack of awareness creation activities in normal times thus inconsistent with the guide line provided by the standing orders on disasters.

Table 8.2: Major Organizations Provided Assistances for Community based Awareness Creation

Name of The Organization		Study unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
BRDB	n	16	7	6	5	10	4	48
	%	48.48%	41.17%	42.85%	62.5%	27.28%	26.67%	38.02%
PRASHICA	n	8	5	7	1	16	4	41
	%	24.24%	29.41%	50.0%	12.5%	44.44%	26.67%	33.33%
CARE	n	4	4	1	1	5	5	20
	%	12.12	23.52%	7.14%	12.5%	13.89%	33.33%	16.26%
CARITAS	n	5	1	0	1	5	2	14
	%	15.15%	5.88%	0%	12.5%	13.89%	13.33%	13.38%
Total	n	33	17	14	8	36	15	123
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Source: Questionnaire Survey, June-October, 2016

8.5.2 Dissemination of SLR Information and Community Preparedness in the Study Unions

Specific guidelines on disasters have been provided for various local level organizations through Standing order during different stage of disaster. Such guideline includes information centre at union level linking union Parishad members, disaster management committee ensure distributing of hazard sending special to the possible location; and advice all concerned people to act accordingly based on weather forecasting broadcasted in radio and television. The present section of this study provides a concise overview about the perception of respondents regarding the spreading of information by various organizations at study areas.

This study finds that 65.78% of total respondents are received information of SLR. Significant difference exists among the areas in terms of receiving early warning information. More than 80% of respondents in Munshigonj, 70% of respondents in Khurushkul are informed about SLR. Distribution of information was much lower in distant unions. Such weaker dissemination of information is linked with locational disadvantage of Islands in terms of communication and transportation networks. On the other hand, due to the proximity to the thana (sub-district) headquarters nearer unions receive information quicker. In coastline unions no local government representatives (union Parishad chairman or members) were available and absence of NGO activities (except very few micro-credit NGOs) put Islanders most disadvantaged situation to take any precautionary coping measures than interior unions. Therefore, though government has prioritized remote areas for distribution of information, but such initiatives are still lacking behind which urge urgent attention to reduce vulnerability of the inhabitants of coastline areas. Apart from the locational exposure of inhabitant's, the present study also explores role of respondent's gender, education, primary occupation and income level in receiving organizational assistance for SLR information. It reveals that more number of female headed households were failed to receive any types of SLR information in compare to the male headed households. Significant difference exists between male and female headed households in terms of receiving organizational assistance regarding SLR information. Therefore, female headed household remain more vulnerable to climatic hazard like SLR.

Table 8.3: Information about Sea Level Rise

Information of Sea Level Rise		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Yes	n	59	40	30	30	60	31	250
	%	81.94%	55.6%	52.6%	61.2%	71.4%	67.4%	65.78%
No	n	13	32	27	19	24	15	130
	%	18.05.8%	44.4%	47.4%	38.8%	28.6%	32.6%	34.21%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Chi-Square	Value=17.543, df=5, p=0.000							

Similarly, education level of respondent plays significant role in receiving organizational assistance regarding SLR. It reveals that higher the education levels of household head, greater the availability of organizational assistance related SLR information. However, such findings could be linked with more access of educated households to broadcast media and close link with information disseminating organizations which enable them to receive information quickly then illiterate households. Similarly, occupation of respondent plays a vital role regarding the receiving of organizational assistance for information. Such finding could be directly associated with education level of the household heads. Service holder and businessmen are mostly educated while fishermen and maidservants are mostly illiterate. Therefore, service holder and businessmen are more likely to receive organizational assistance for information of SLR. Similarly, organizational assistance for SLR significantly varies according to the income level of household head. It reveals that households with higher income had received more assistance regarding SLR information than lower income households. Households having good socio-economic status are more likely to receive better organizational assistances for SLR.

Table 8.4: Organizational Assistances for Information Regarding Danger of Sea Level Rise

Area	Information of SLR					
	Yes		No		Total	
Union	N	%	N	%	N	%
Munshigonj	58	80.55	14	19.44	72	100.00
Gabura	21	29.16	51	70.83	72	100.00
Lalua	24	42.10	33	57.89	57	100.00
Nilgonj	29	59.18	20	48.88	49	100.00
Khurushkul	61	72.62	23	27.38	84	100.00
Bharuakhali	19	41.83	27	58.70	46	100.00
Total	212	55.79	168	44.21	380	100.00

Source: Questionnaire Survey, June-October, 2016

This study finds that among the surveyed respondents 55.79% are informed about the information regarding SLR. Danger of SLR is conveyed to the communities by different media. The present study reveals that the people who stay nearer to head quarter of administration generally very much aware of information. In Munshigonj 80.55%, Khurushkul 72.62% of the respondents are aware of the Information of SLR. Comparatively these two unions are attached to upazila administration. This study reveals that people stay comparatively in distant location are weaker regarding getting information like Gabura 29.16 %, Lalua 42.10 % and Bharuakhali 41.83% of the respondents. Bangladesh Red Crescent Society Volunteers play a vital role in distributing information among the villagers in different unions, while radio broadcasting and words of mouth from neighbors were the major sources of information among all study unions. Local government officials and NGOs play a vital role in study areas which is close to the sub-district (upazila) headquarter. However, such finding is consistent with previous study that local government officials were more important source of information in urban areas than remote Islands.[7] The informations were widely received in Inland and coastline communities than Islanders from different primary sources. However, in general radio broadcasting and words of mouth from neighbors or relatives were the most common sources of information in all study locations.

8.5.3 Disaster Risk Reduction through Enhancing Community Coping, Resiliency and Rebuilding Livelihoods

Exposed coastal area of Bangladesh is highly vulnerable to different climatic hazards. So, some necessary directions on disasters have provided for a complete guideline for local government organizations about their responsibilities during disaster stage. Some of these responsibilities are ensuring different training for the resiliency of livelihood, publicity of danger, evacuation of vulnerable inhabitants and livestock to the safer places etc. It reveals that organizational assistance for livelihood security is comparatively higher concentrated in interior area. While few of the organizations assist the inhabitants of exposed areas.

It is found in the present study that unavailability of organizational assistances for required training support and information deprive the inhabitants to take proactive adaptation strategies during hazards. Closeness to thana headquarter with good communication network was the main advantage of interior areas for receiving necessary

[7] C. Emdad Haque, "Climatic Hazards Warning Process in Bangladesh: Experience of, and Lessons from, The 1991 April Cyclone," *Environmental Management* 19, no. 5 (1995): 719.

assistances. In the present study location for livelihood security agriculture, Fishery, Livestock, Poultry etc. are the most effective sectors which are to be considered with proper steps to make the inhabitants resilient in any consequences of disaster.

The present study finds that coastal people take assistance for agricultural activities; here it is mentioned that agriculture is one of the major sources for livelihood option. Moreover, people in other occupation in the coastal area involve themselves in agriculture. About 42.40% people of the study are got different support from agriculture extension workers (table 8.4) and different NGOs. As the area is climatic hazard prone so maintenance, instructions and guidelines are essential for this type of hazardous area. The study finds that the type of assistance provided are process of using seed and fertilizer, insecticides, cows and goats caring etc. Inhabitants of Nilgonj (61.2%), Lalua (47.4%), Munshigonj (45.8%) and Gabura (44.4%) have got higher assistance in agriculture followed by Khurushkul (28.6%) and Bharuakhali (32.6%). A major portion of people of Khurushkul and Bharuakhali are involved in salt industry. During time of field study conversation with upazilla administration it was found that a monitoring exists from agriculture extension department in the area. However, significant difference exists among the areas regarding the assistance taking for agriculture.

Table 8.5: Assistances Provided by Agriculture Extension Worker

Assistances of Agriculture Extension Worker		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Yes	n	33	32	27	30	24	15	161
	%	45.8%	44.4%	47.4%	61.2%	28.6%	32.6%	42.4%
No	n	39	40	30	19	60	31	219
	%	54.2%	55.6%	52.6%	38.8%	71.4%	67.4%	57.6%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Chi-Square	Value=16.543, df=5, p=0.000							

Source: Questionnaire Survey, June-October, 2016

In the coastal belt of Bangladesh a significant part of population are involved in fishery, livestock and poultry section for their livelihood option. Over the time it is seen that the inhabitants of the area face permanent loss due to devastating climatic events. For the security of livelihood option or making the inhabitants resilient assistance is immense need in the coastal zone of Bangladesh. The study finds that the inhabitants of the study area get training assistance regarding Fishery, Livestock and poultry section. It also finds that the people live closer to administrative headquarter area is a major portion who get better assistance. In this way Nilgonj (49.0%), Khurushkul (46.4%) and Munshigonj (33.3%) are in higher portion followed by distant location Gabura (22.2%), Lalua (19.3%) and Bharuakhali (71.7%) (table 8.5).

During field study conversation with NGOs personnel it was found that different NGO's working to promote fisheries aquaculture as promotion of salt tolerant species, rehabilitation of degraded habitat and maintenance of fish migratory routes, improve design and construction quality of fishing boat having capacity to safe return to shore during bad weather condition.

In the time of field study different FGD with local people it was found that a monitoring exists relevant department in the area. However, significant difference exists among the areas regarding the assistance taking for fishery, livestock and poultry sector.

In the study area significant portion respondents mentioned that they receive assistances for safer practices of various livelihood options. As the exposed coast area is low lying, potential impact of sea level rise will inundate major portion of area with salinity and which will create major environmental change. Based on the FGD with the people of the locality it is found that their livelihood options are seriously threatened with the upcoming impact of sea level rise. Therefore, non-existence of the activities or inaction of such steps in remote locations needs to be taken care for better preventive measures in future threats of SLR.

Table 8.6: Assistance for Fishery, Livestock and Poultry

Assistance for Fishery, Livestock and Poultry Training		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Yes	n	24	16	11	24	39	33	147
	%	33.3%	22.2%	19.3%	49.0%	46.4%	71.7%	38.7%
No	n	48	56	46	25	45	13	233
	%	66.7%	77.8%	80.7%	51.0%	53.6%	28.3%	61.3%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Chi-Square	Value=43.630, df=5, p=0.000							

Source: Questionnaire Survey, June-October, 2016

8.5.4 Foreign Assistance to Combat Climatic Disaster in the Study Area

Various adaptation measures are in practice in the study areas to combat adverse impacts of climate change induced SLR disasters. These are implemented by GO, NGO, CBO and Indigenous/local programs etc. Simultaneously, in vulnerable coastline of Bangladesh some donor countries participations are found. In the study area respondents were asked to give information about the livelihood security practices provided by the foreign supports. 37.9% of the total respondents agreed about the support provided by the foreign countries (table 8.6). Bharuakhali (60.9%), Khurushkul (44.0%) and Nilgonj (36.7%) are the highest supported areas by different programs of foreign countries. In this area USAID supported different programs are found. In Khurushkul union primary school cum cyclone centers have been made under different projects supported by Saudi Arabia. Some projects financed and supported by UAE, Canada, France are found in the study area (see appendix table 6).

Table 8.7: Foreign Assistance for Climatic Disaster of the Study Area

Foreign Country Support		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Yes	n	26	25	10	18	37	28	144
	%	36.1%	34.7%	17.5%	36.7%	44.0%	60.9%	37.9%
No	n	46	47	47	31	47	18	236
	%	63.9%	65.3%	82.5%	63.3%	56.0%	39.1%	62.1%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Chi-Square	Value=22.132, df=5, p=0.000							

Source: Questionnaire Survey, June-October, 2016

Basic goals of these projects are to ensure shelters during disasters, ensuring drinking water, health and education support.

8.5.5 Satisfaction Level of Respondents about Foreign Support

Through questionnaire survey and focus group discussion, it has been tried to understand the level of satisfaction of the local people about the foreign support for disastrous climatic events of the study area. Different foreign countries undertook a number of programs to address SLR impacts. During household survey and focus group discussions, respondents have been asked to give a value against each project according to their effectiveness. They all gave scores against the project completion scenario. Such scoring gives an idea about the effectiveness of each project. Scale was used for evaluating the effectiveness of projects which are designed and practiced to reduce sea level rise impacts. From this evaluation it was tried to find out the level of satisfaction of foreign country's support. Respondents of Bharuakhali (76.1%), Khurushkul (67.9%) and Nilgonj (61.2%) are comparatively more satisfied about the support of foreign countries as there are some foreign projects and supports are going on in the area. Support centre are found comparatively less in Lalua (47.4%), Gabura (45.8%) and Munshigonj (45.8%) (table 8.7). Main cause is that these locations are situated in remote part of the coastal area. So, it is detected that remote parts are vulnerable to any climatic hazards.

Table 8.8: Satisfaction Level of Inhabitants about Foreign Support

Level of Satisfaction		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Not satisfied	n	5	9	5	8	22	10	59
	%	6.9%	12.5%	8.8%	16.3%	26.2%	21.7%	15.5%
Moderately satisfied	n	34	30	25	11	5	1	106
	%	47.2%	41.7%	43.9%	22.4%	6.0%	2.2%	27.9%
Satisfied	n	33	33	27	30	57	35	215
	%	45.8%	45.8%	47.4%	61.2%	67.9%	76.1%	56.6%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Likelihood Ratio	Value=67.469, df=5, p=0.000							

Source: Questionnaire Survey, June-October, 2016

8.5.6 Level of Satisfaction on Provided Service and Information by Different Organizations

This section of the study tries to find out the level of satisfaction on provided service and information by different organization like GO, NGO, CBO and local individual people in response to sea level rise problem in six selected unions of respective upazilas. For this purpose, following tools have been used. Different government and non-government organizations have been interviewed as key informants regarding their programs in response to SLR in study area.

At the same time local people have been asked through questionnaire survey regarding their perspective about the effectiveness of ongoing projects. During filling up the questionnaire, people gave scores against the project scenario. Three point likert scale has been used to understand people's perception regarding the effects of projects, which has been presented in detail in table 8.8. Questionnaire survey was conducted in selected area of three upazilas for information.

The study finds that 56.3% of the respondents are satisfied about the services provided by the different organizations, 42.6% respondents are moderately satisfied and fewer (1.1%) are not satisfied.

Table 8.9: Level of Satisfaction on Provided Service and Information by Different Organizations

Level of Satisfaction		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Not satisfied	n	3	1	0	0	0	0	4
	%	4.2%	1.4%	0.0%	0.0%	0.0%	0.0%	1.1%
Moderately Satisfied	n	44	39	35	12	18	14	162
	%	61.1%	54.2%	61.4%	24.5%	21.4%	30.4%	42.6%
Satisfied	n	25	32	22	37	66	32	214
	%	34.7%	44.4%	38.6%	75.5%	78.6%	69.6%	56.3%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Likelihood ratio	Value=59.136, df=10, p=0.000							

Source: Questionnaire Survey, June-October, 2016

8.6 Chapter Summary

The present study finds that a number of organizations provide assistance in the study unions. Governmental organization includes Union Parishad, Agricultural extension, Bangladesh Krishi Bank and Upazila Nirbahi Office. From FGD it finds that local government organization Union Parishad (UP) provides comparatively better rehabilitation activities. Upazila Nirbahi Office plays a vital role for the rehabilitation activities. Apart from this, government take initiatives to support food insecure population in the study area.

Apart from government bodies different non-government organizations play a vital part for Assistance. However, such organizations are not same across the unions. In interior unions like Munshigonj, Nilgonj and Bharuakhali major NGOs were BRAC, World Food, Sankalpa, Ahasania Mission. Likewise, major NGOs were BRAC, World Food, Save the children, Heed Bangladesh, Health Care, Sankalpa, Songram, Islamic Foundation and Food for Hunger were found in the study unions. Agricultural extension department provides seeds and fertilizer to the farmers. However, such support was in very limited scale in terms of demand in the study area.

Ahasania Mission a national NGO provides support to the fishermen of Inland village for livelihood rebuilding. The organization had formed cooperatives among the fishermen and provided boat with a pre-condition that fishermen will buy the engine of boat from their own source. However, such effort was not successful to help rebuilding livelihoods of fishermen. Similarly, BRAC had distributes few cows among its members. Some foreign donor countries work in the study unions. The donor countries established a number of safe shelters in the study area. The mentionable countries are Saudi Arabia, Malaysia, U.S.A etc.

In the present study an attempt has also been made to assess the satisfaction of respondents on different support services provided by different government and non-government organizations in all six unions. Significant percent of total respondents were satisfied on support services provided by various organizations. However, very few respondents in interior unions were not satisfied on such services.

Table 8.10: Summary of Institutional Assistances for Enhancing Adaptation and Livelihood Security in Study Unions

Institutional Assistance Mechanisms	Study Unions						Total
	Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Awareness Campaign	45.8%	23.6%	24.6%	16.3%	42.9%	32.6%	32.4%
Organizational Assistances (No. of Persons)	33	17	14	8	36	15	123
SLR Information	80.55%	29.16%	42.10%	59.18%	72.62%	41.83%	55.79%
Agricultural Assistance	45.8%	44.4%	47.4%	61.2%	28.6%	32.6%	42.4%
Fishery, Livestock Support	33.3%	22.2%	19.3%	49.0%	46.4%	71.7%	38.7%
Foreign Aid	36.1%	34.7%	17.5%	36.7%	44.0%	60.9%	37.9%
Satisfaction level for Foreign Support	45.8%	45.8%	47.4%	61.2%	67.9%	76.1%	56.6%
Satisfaction level for Local Support	34.7%	44.4%	38.6%	75.5%	78.6%	69.6%	56.3%

Source: Questionnaire Survey, June-October, 2016

The government of the country has a well-established set-up of disaster management institutions in all departments and administrative tiers. Among them the Comprehensive disaster management plan and standing orders on disaster are successful initiatives for disaster management at policy level. Sea level rise is a burning problem in the study areas. Sea level rise preparedness program has given priority by the government of Bangladesh to reduce future disaster risk in coastal areas. Community risk assessment and participatory risk reduction action plans are some of the successful initiatives to involve community in disaster risk reduction process. Similarly, reducing risk factors such as building cyclone shelters, introducing saline and drought tolerant crop verities, coastal aforestration and introducing disaster management issues in education system have proven fruitful in recent years.

Some efforts developed by both GO and NGO collaboration for sustainable coastal zone livelihood security was not expected successful. Main problem from NGOs side was limited funding and main problem from government's side was lack of willingness and lack of skilled and passionate employees. On the other hand, there are a good number of local NGOs devoted to reduce the SLR induced disasters. For getting expected or fruitful outcomes for the people they should be organized. There is still lack of awareness among local people regarding adaptation measures for potential impact of sea level rise. They give preference to various SLR adaptation strategies developed by Government, NGO, CBO and some indigenous programs of locality. The study finds that inhabitants of remote coast area receive comparatively lesser and delayed information of climatic events and other assistances which make them more vulnerable to coming disasters and unlikely to achieve potential livelihood security. Similarly, different government and non-government organizations are concentrated on the areas located close to the thana headquarters or having good communication networks. Therefore, special attention should be given to the distant Islands and remote char-lands at local level for future climatic disaster risk reduction.

Similarly, local government officials need to strengthen their activities for better management of disastrous events. Rehabilitation activities should acknowledge the real needs of climatic victims. Future income generating activities or livelihood rebuilding need to be prioritized to combat the future of climate change induced sea level rise as the present study finds 'food for work' and 'cash for work' were most effective to save the victims from starvation. Besides, coordination among different NGOs and local government organizations is pre-requisite for ensuring resilience of the inhabitants.

Chapter Nine
Assessing Livelihood Security

9.1 Introduction

This chapter attempts to find how livelihood security can be achieved by organizing resources, capabilities and regular activities along with adaptation strategies for ensuring access to the basic needs in disaster prone coastal Bangladesh. Different households usually have differential access to various resources/capitals (namely natural, physical, financial, human and social) to earn means of living. Households use these resources in a combination while face adversity, household usually adopts a ranges of coping and adaptation strategies. In study areas disastrous events of climate are such adversities recurrently faced by coastal households. A wide range of coping and adaptation measures are identified in present study that households usually adopts to overcome the crisis posed by recent and upcoming period. Various institutions works at community setting not only influence households coping strategies but also livelihood security outcomes. A brief overview of different government and non-governmental initiatives to reduce disaster risk and rebuilding livelihoods particularly with reference to the coastal disasters are provided in the previous chapter. Government organizations not only give support services but also provide safety nets and various policies that might favorably or adversely influence livelihood system. Similarly, various non-government organizations, informal community based networks and private organizations can create enabling environment or limits households to pursue livelihoods strategies for coastal area.

Coastal people use various livelihood resources and institutional connections within a certain context to pursue various livelihood options such as production and income generating activities or combination of both. However, success of household's livelihood strategies can be measured through various outcomes. Such outcome measures include sustainable access to food, nutritional status, access to education, healthcare services, housing, sanitation etc. However, food and nutritional status of households are considered as relatively better outcome measures of livelihoods security; since these include various dimensions such as access to food, healthcare facilities and educational status. Considering these multiple dimensions of livelihood security, the present section of this study attempts to identify different outcomes of livelihood security such as food, nutritional security, educational security, housing, sanitation and health security in the context of potential impact of sea level rise in the coastal region of Bangladesh. A number of standard indicators are used to measure such livelihood security outcomes of the coastal people of Bangladesh.

9.2 Determining Livelihood Security: Conceptual Considerations

Analysis of livelihood is complex. Livelihood security refers to the ability of the household to meet its basic needs. It is defined in the present study as household's ability to sustain and increase income, assets and well-being to meet-up the basic needs from one year to another. Such basic needs include availability and access to food, drinking water, education, shelter, healthcare, and involvement in community and social integration etc.[1] Livelihood comprises various indicators of on-farm and off-farm activities that collectively provide a number of strategies to procure food and cash.

Livelihood activities depends on households entitlements, and such entitlements are based on mainly household's endowments which comprise its livelihood.[2] The risk of the failure of livelihood determines the households' level of vulnerability to income, food, nutrition, health and other livelihood security measures. If a household spend large share of resources to procure food and healthcare services, the likelihood of being vulnerable to food and nutritional insecurity increases. Therefore, household having secure ownership and/or access to various types of resources (livelihood capitals) and income earning activities to face the adversities is considered as secured livelihood.[3] When households are secured regarding livelihood they are able to obtain, defend, develop exchange and gain from resources and assets.

To measure livelihood security, it is necessary to consider a number of outcome measures that include household's needs and well-beings. Nutritional status of a household is considered as one of the most effective outcome indicators of livelihood security. Apart from household nutritional status of household other possible basic need indicators are

---

[1] Timothy Frankenberger, "Measuring Household Livelihood Security: An Approach For Reducing Absolute Poverty," In *Food Forum*, vol. 34(1996): 1.

[2] M. Drinkwater and M. McEwan, "Household Food Security and Environmental Sustainability in Farming Systems Research: Developing Sustainable Livelihoods," *A Paper Presented to the Adaptive Research Planning Team* (1992): 13.

[3] R. Chambers, "Sustainable Livelihoods, Environment and Development: Putting Poor Rural People First, Institute Of Development Studies and Poverty Research Unit," *IDS Discussion Paper* 20(1988): 11.

access to adequate and nutritional food, healthcare facilities, housing, basic education, and minimum income level etc. If any of the households failed to meet any of the basic needs considered to be living in below poverty line.[4] However, simply satisfying such basic needs do not necessarily always reflect individual household's poverty level.

Similarly, approaches to examine household's level of well-being are not new experience, the earliest initiative for the development of a scale for measuring household's level of living was started by many scholars. Overseas Development Council developed an index as physical quality of life index to measure quality of life. This index has also limitations in combining social and economic aspects of households in one composite index. Since then a number of frameworks for assessing livelihood security at household level were developed by various organizations.

In 1990s, Frankenberger and his colleagues had successfully applied these for relief, rehabilitation and development programs for various non-profit organizations. CARE international has conducted more than 50 household livelihood security studies in 40 countries including Bangladesh by 2000. A number of modifications and further refinement has been done in the earlier framework based on the previously conducted studies during 1997-2001. In 1996 this approach was applied in Kenya and from this project some modifications were made and later it was applied in India and Srilanka.[5]

The livelihood security index prepared by CARE international has eight sub-components. These include income, assets, food, nutrition, education, water, sanitation, primary health, reproductive health, and community participation. Five point ordinal scale was used for each of the indicators to rank according to the availability, accessibility, quality and status of household. Each of the indicators can be presented separately, and in a group to depict the collective measure of livelihood security based on equal weight of each of the components. The eight sub-components are grouped into five categories to present livelihood security, such as food, economy, health, education and empowerment. However, disagreement also took place regarding the appropriateness of using aggregate index of eight sub-components. Though having limitations of using separate indicators for

[4] Timothy Frankenberger, "Measuring Household Livelihood Security: An Approach for Reducing Absolute Poverty," In *Food Forum*, vol. 34(1996): 2.

[5] Marc Lindenberg, "Measuring Household Livelihood Security at the Family and Community Level in the Developing World," *World Development* 30, no. 2 (2002): 302.

measuring livelihood security is relatively more useful than aggregate index. Therefore, in most of the recent studies CARE do not use aggregate index for measuring livelihood security. Considering the limitations of aggregate indexing of livelihood security indicators, the present chapter of this study focuses on separate and individual indicators for measuring livelihood security under the board categories of food security, nutritional security, shelter water and sanitation security, health security, economic and educational security. Various relevant indicators are used in each category to present the livelihood security outcomes for the purpose of the present study.

9.3 Measuring Household Food Security: Discussion on Sample Households

In Bangladesh a significant part of population experience continual as well as transitory food insecurity. More recently three factors are identified which worsen the household food security such as devastating monsoon flood and catastrophic climatic events and rising prices of food and other essential commodities.[6]

Number researches are available on food security and hunger in Bangladesh. Few of them explicitly focused on conceptual and perceptional dimensions of food security. Some focused on macro level food production, supply and national food policies, some discussed on poverty, welfare and nutrition measurement parameter and debates,[7] and some experiences of hunger, poverty, and disempowerment at individual level. Despite of the availability of a number of literatures on food security issues in Bangladesh, role of CC-induced disaster damage, livelihood capitals and coping and adaptive measures to define future disaster triggered household food security are relatively unidentified.

Moreover, climatic events are the major impediments in coastal Bangladesh for achieving food security. After the occurrence of any disastrous event millions of people lose their shelters and assets needed for their livelihoods. Despite of having considerable economic recovery and reconstruction efforts thousands of households remained food insecure in coastal Bangladesh. The present section of this study intends to explore food security status in terms of disastrous climatic event like sea level rise and identify role of different factors including relevant loss, household demography, socio-economic variables, livelihood assets and coping measures to define future household food security in the study areas.

[6] FAO, Special Report FAO/WFP Crop and Food Supply Assessment Mission to Bangladesh (2008), retrieved from http://www.fao.org/docrep/011/ai472e/ai472e00.htm (Accessed on 11 June 2016).

[7] Amartya Sen, "Famines," *World Development* 8, no. 9 (1980): 613.

9.4 Determinants of Food Security and Measuring Techniques: A Brief Review

Food insecurity is triggered by the failure or failure of food availability either at local, regional, national or global level. Next, in1980s, a paradigm shift has taken place while Amartya Sen claims that it is more concerned with people's access to food than availability at different levels. From that time it is accepted that food insecurity is a problem of access to food at individual or household level than national or global level. Recently food security is conceptualized as all-time physical, social and economic access to adequate safe and nutritious food for an active and healthy life. Similarly, people are food secure if consumption of such food is sufficient, secure and supportable in case of consumption deficits.[8]

Food security is a function of numerous factors that allow individuals to access nutritionally adequate and safe food in proper ways, including employment, education and community variables. There is no single index for measuring household food security. Consumption, poverty and malnutrition are used as proxy measures; and assets and income is used as determining factor.[9] Day long recall data for actual food consumption at household level could be better one for measuring food security.[10] However, until recently most common traditional measure of food access is calorie adequacy. All such measures take into account adequacy of food quantity but do not necessarily deal with its quality or issues of vulnerability or sustainable access to food. Accordingly, occurrence and severity of coping strategies related to food consumption is also used as alternative indicators of measuring food security.[11]

So, measuring household food security in a standard valid and reliable way is a challenging task. However, wealth of literatures is available on measuring food security as an indicator of livelihood security through coping strategies in different contexts.

In present study per capita calories intake per day is used as a dependent variable; because household food availability is a function of expenditures for food, household demography, assets, coping measures and household dietary preferences as well. Besides, some other

[8] Daniel G Maxwell, "Measuring food insecurity: the frequency and severity of "coping strategies"," *Food policy* 21, no. 3 (1996): 294.
[9] Ibid., 295.
[10] Ibid., 296.
[11] Ibid., 297.

subjective measures are also used to support the findings of calorie intake such as self-reported household food availability, and anxiety for future food requirement etc.[12]

Food insecurity is a complex issue which depends on various demographic and socio-economic aspects of individual household. For example household's income below poverty line, female headed households with bigger family size, ethnic groups and older adults are often exposed to food insecurity. Similarly, landownership, education, age are also noteworthy factors of food insecurity. Assets play a vital role for securing household's food consumption. Adequate food consumption is often constrained by limited assets and savings. Several earlier studies reveled that household food security is positively related with income level. On the other hand, resource availability, competing demands, and coping strategies are the three mechanisms accounted for household food insecurity.[13] Competing demand of economic resources may create exchange between food and other necessities such as childcare and healthcare. Therefore, households having limited resources, lower level of expenditures on food items and higher expenditure on other purposes may lead to higher risk of food insecurity.

In this regard, household having similar financial conditions and competing consumption requirements; households with relatively better adopted coping strategies and financial solvency might help to manage resources effectively which will make them more food secured.

9.5 Household Food Security for Impending Impact of SLR: Subjective Measures

Some earlier studies had revealed that assessing household food security through a single variable is a difficult task. Hence, the present study attempts to measure food security by using different methods including the provision of adequate food, perception and satisfaction about adequacy of food either in quantity and quality, anxiety about future food budget or food supply, and finally per capita calories intake per day. Different subjective measures are used in this study to support the findings of food security estimation based on calorie consumption.

---

[12] Anne Swindale and Paula Bilinsky, "Development of a universally applicable household food insecurity measurement tool: process, current status, and outstanding issues," *The Journal of nutrition* 136, no. 5 (2006): 1450S.

[13] Katherine Alaimo, Ronette R. Briefel, Edward A. Frongillo Jr and Christine M. Olson, "Food insufficiency exists in the United States: results from the third National Health and Nutrition Examination Survey (NHANES III)," *American Journal of Public Health* 88, no. 3 (1998): 421

9.5.1 Household Food Availability

Examining the number of months that household can manage to feed adequate food to all members in a year is important for assessing household food availability. To answer this question following section provides a brief overview of different aspects of food security, especially perception about average monthly food availability, and per capita rice consumption. Considering per capita rice consumption in normal and crisis months a percentage decline in per capita rice consumption is calculated [(normal intake – crisis months intake) / normal intake) * 100].

Table 9.1: Number of Months Household had Adequate Food to Feed All Members

Adequate Food (in months)		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
1-4 months	n	10	9	18	8	9	15	69
	%	13.9%	12.5%	31.6%	16.3%	10.7%	32.6%	18.2%
4-8 months	n	31	34	35	20	24	20	164
	%	43.1%	47.2%	61.4%	40.8%	28.6%	43.5%	43.2%
8-12 months	n	31	29	4	21	51	11	147
	%	43.1%	40.3%	7.0%	42.9%	60.7%	23.9%	38.7%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Average Months		8.14	7.10	6.29	8.10	9.08	7.10	7.64
Likelihood Ratio	Value=52.999, df=10, α=0.000							

Source: Questionnaire Survey, June-October, 2016

The present study finds that average 7.64 months for total respondents of all six unions and 8.14, 7.10, 6.29, 8.10, 9.08 and 7.10 months in Munshigonj, Gabura, Lalua, Nilgonj, Khurushkul and Bharuakhali union respectively could manage adequate food for respective households in a year (table 9.1). In general, different households experienced 3 to 4 months of deficit in food supply. Significant difference exists among the villages in terms of the availability of adequate food for the households (Likelihood ratio Value = 52.999, df =10, α = 0.000).

It reveals that adequate food for all the members in household is available for 8-12 months Khurushkul (60.7%), Munshigonj (43.1%), Nilgonj (42.9%), Gabura (40.3%) and comparatively less in Bharuakhali (23.9%) and Lalua (7.0%). On the other hand adequate food for all members is higher in Lalua (61.4%), Gabura (47.2%), Bharuakhali (43.5%), Munshigonj (43.1%), Nilgonj (40.8%) and Khurushkul (28.6%). In contrast, adequate food for all members for 1-4 months Bharuakhali (32.6%), Lalua (31.6%), Nilgonj (16.3%), Munshigonj (13.9%), Gabura (12.5%) and Khurushkul (10.7%) respectively. Here, it is found that Gabura, Lalua and Bharuakhali which are situated nearer to coast are vulnerable to any future adverse situation.

9.5.2 Household's Perception about Adequacy of Food Consumption Per Day

To determine food security of household level measuring perception about food consumption is very important tool. During the time of field survey respondents were asked to express the level of adequacy of food consumption. Moreover, they were asked to assess about the adequacy of quality and quantity of food. To answer this question household head's perceptions about quantity and quality of food consume per day per capita was assessed. About one fourth of total respondents mentioned that the amount of food they usually consume is adequate. However, significant difference exists among the villages regarding the perception about the quantity of food they consume (Chi-square Value= 32.617, df= 5, α= 0.000).

About 16%, 8%, 38%, 20%, 28% and 47% of the respondents of Munshigonj, Gabura, Lalua, Nilgonj, Khurushkul and Bharuakhali respectively perceived to adequate food in terms of quality and quantity. On the other hand 83.3%, 91.7%, 61.4%, 79.6%, 71.4% and 52.2% of the respondents of Munshigonj, Gabura, Lalua, Nilgonj, Khurushkul and Bharuakhali respectively presented their view of food consumption is inadequate (table 9.2). It is identified that some locations are vulnerable in terms of any future adversity.

A day long recall data regarding food consumption shows that the coastal rural people usually depend on rice to meet daily calorie requirements. Other nutrient components such as protein, fat and vitamins are almost missing in daily food menu. Therefore, majority of the respondents mentioned that the quality of food usually they consume is not sufficient to meet the daily calorie requirements. Five point Likert scale was used to measure the satisfaction of respondents regarding the quantity and quantity of food usually they consume.

Table 9.2: Household's Perception about Adequacy of Food Consumption per Day

Food Adequacy		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Adequate	n	12	6	22	10	24	22	96
	%	16.7%	8.3%	38.6%	20.4%	28.6%	47.8%	25.3%
Inadequate	n	60	66	35	39	60	24	284
	%	83.3%	91.7%	61.4%	79.6%	71.4%	52.2%	74.7%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Chi-square	Value=32.617, df=5, α=0.000							

Source: Questionnaire Survey, June-October, 2016

9.5.3 Household’s Anxiety for Future Food Consumption

Apart from assessing individual household’s food availability, food insecurity also depends on anxiety for not having sufficient food or feel anxiety and uncertainty for future food consumption. Level of anxiety might be varied based on the level of existing food insecurity. For instance, least severe case of food insecurity household head may feel anxiety for not having enough food, which could resulted in the compromises with food preferences and consumption. In contrast, severe case of food insecurity implies household might fall in absolute level of food deprivation which resulted in failing to eat because of not having food with higher level of anxiety. However, measuring anxiety is not an easy task. It requires expertise economics and nutrition science with knowledge about psychometric theories or methods. In present study household’s anxiety for food is assessed in a simple way based on the perception of respondent about the concern for future food consumption.

The present study finds that in terms of future climatic event such as SLR more than 77% of respondents were worried about future food consumption. Significant difference exists among the villages regarding respondent’s anxiety for future food supply, which are as 79.2%, 87.5%, 80.7%, 69.4%, 78.3% and 71.7% respectively for Munshigonj, Gabura, Lalua, Khurushkul and Bharuakhali (table 9.3). More number of households with higher level of anxiety for future food consumption was found in Gabura and Lalua Union. It clear that future climatic events like SLR will further aggravate the situation.

Table 9.3: Household's Anxiety for Future Food Consumption

Anxiety		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Yes	n	57	63	46	34	62	33	295
	%	79.2%	87.5%	80.7%	69.4%	73.8%	71.7%	77.6%
No	n	15	9	11	15	22	13	85
	%	20.8%	12.5%	19.3%	30.6%	26.2%	28.3%	22.4%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Chi-square		Value=7.989, df=5, p=.000						

Source: Questionnaire Survey, June-October, 2016

9.5.4 Measuring Household Food Security Based on Per Capita per Day Calorie Consumption

Despite the subjective measures, present study employed per capita calorie consumption per day per person to assess the household future food security status in terms of various climatic events. The households that consumes below the minimum requirements of food in terms of available calories based on age, sex and activity of members are considered as food insecure. However, there is no universal agreement to use certain amount of calories as a benchmark unit or cut off point for delineating food secure and insecure groups. The estimation of basic requirements to meet minimum food needs range between 1885-2500 kilocalories.[14] In the case of Bangladesh the minimum calories intake comparing with the minimum requirement of 2122 Kilocalories is determined by World Health Organization (WHO) and the minimum requirement for a normal working person of 2310 Kilocalories by Food and Agricultural Organization (FAO). In present study, cut-off point of 2122 kcal per adult per day per person is used to delineate the food insecure group according to the benchmark of the minimum calorie requirement for Bangladesh by World Health Organization (WHO).

According to the Household Income and Expenditure Survey (2011) about 24 percent of the rural populations consume less than 1805 Kilocalories, roughly 23 percent consume 1805-2122 Kilocalories. For the purpose of present discussion these groups are termed as 'hard core food insecure (>1805 kcal)' and 'moderately food insecure (1805-2122 kcal)

[14] Vaclav Smil, "How Many People Can The Earth Feed?" *Population and Development Review* (1994): 257.

and food secure (>2122 kcal).[15] It reveals that 22.6% percent of total respondent fall in the category of hard core food insecure, 25.8% percent in moderately food insecure and 51.6% percent are food secure in terms of per capita calorie consumption. Significant difference exists among the villages in terms of per capita calorie consumption (table 9.4). Moreover, any future disruption of food supply will make the situation more unsafe.

Highest percentage of food secure population was found in Khurushkul (73.8%), Nilgonj (69.4%) and Munshigonj (58.3%) followed by Bharuakhali (41.3%), Gabura (38.9%) and Lalua (19.3%). Similarly, calorie availability significantly varies among different livelihood groups. The present study finds that relatively higher number of 'hard core food insecure' households belong to wage labor group, while lower number of 'food secure' households belong to the same group. This reveals that significantly wage laborer group are more vulnerable group in terms of any occurrence of climatic event like sea level rise than farmer and fisher livelihood groups. On the other hand, among the livelihood groups' farmer reveals relatively higher level of food security than fisher and wage laborer.

Table 9.4: Measuring Household Food Security Based on Per Capita per Day Calorie Consumption

Status		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Food Insecure	n	1	29	39	0	1	16	86
	%	1.4%	40.3%	68.4%	0.0%	1.2%	34.8%	22.6%
Moderately Secure	n	29	15	7	15	21	11	98
	%	40.3%	20.8%	12.3%	30.6%	25.0%	23.9%	25.8%
Food secure	n	42	28	11	34	62	19	196
	%	58.3%	38.9%	19.3%	69.4%	73.8%	41.3%	51.6%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Likelihood Ratio	Value=145.731, df=10, p=.000							

Source: Questionnaire Survey, June-October, 2016

[15] Bangladesh Bureau of Statistics, *Reports of the Household Income and Expenditure Survey 2010*. 31st ed. Bangladesh Bureau of Statistics, Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh (Dhaka: December 2011), 45.

<u>Empirical Models: Determinations of Potential Sea Level Rise Food Security in the Study Area</u>

Per capita calories intake is considered as a dependent variable in the present analysis assuming that household's post disaster food security is a function of food prices, household income, expenditure, demography and socio-economic factors. Schooling of housewife is considered in this study as maternal characteristics with an assumption of having significant influence on providing care, household expenditure pattern and food preferences. Household's structural characteristics such as family size, number of adult family members, household head's gender, primary occupation, income etc. are included to cover the socio-economic aspects of household (table 9.5) .

Table 9.5: Defining Criteria of Different Selected Variables for Correlation and Regression Model

Variables	Defining Criteria
Per capita calorie intake	Household food consumption divided by the number of adult family members
Age of Respondents	Years of age
Housewife's year of schooling	Schooling years
Gender of household head	Male: 1, Female: 0
Primary occupation of household head	Agriculture: 1, Otherwise: 0
Family size	Total number of family members
Annual household food expenditure	BDT (Annual)
Amount of land	Land (in acre)
Human capital	Index value (0-1)
Natural capital	Index value (0-1)
Financial capital	Index value (0-1)
Physical capital	Index value (0-1)
Social capital	Index value (0-1)

Potential impact caused by SLR is included in the analysis assuming that disaster has significant impact on household food security. Likewise, five types of livelihood capitals, household income, and land holding size are considered in this study as household's endowment assuming such variables have influence on food production and food availability. Apart from the above mentioned selection criteria of such indicators, correlation coefficients of these indicators are also measured. The indicators having statistically significant association with per capita calorie consumption are considered for regression model.

Table 9.6: Correlation Matrix of Different Variables

Correlation Matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	1	.189** .000	.276** .000	.095 .063	.026 .618	.580** .000	.623** .000	.411** .000	.641** .000	.611** .000	.671** .000	.459** .000	.398** .000	.380** .000
2	.189** .000	1	-.014 .779	.038 .461	.120* .019	.027 .594	.173** .001	-.007 .892	.015 .773	.108* .036	-.097 .059	.083 .107	.076 .139	.217** .000
3	.276** .000	-.014 .779	1	.119* .020	.071 .166	.143** .005	.247** .000	.144** .005	.139** .007	.263** .000	.185** .000	.132* .010	.189** .000	.179** .000
4	.095 .063	.038 .461	.119* .020	1	.068 .188	.065 .205	.141** .006	-.024 .639	.006 .901	.089 .082	.082 .112	.251** .000	.090 .080	.115* .024
5	.026 .618	.120* .019	.071 .166	.068 .188	1	.121* .018	.091 .076	-.046 .367	.095 .063	.002 .973	.015 .772	-.018 .724	.429** .000	.125* .015
6	.580** .000	.027 .594	.143** .005	.065 .205	.121* .018	1	.432** .000	.293** .000	.765** .000	.435** .000	.572** .000	.437** .000	.437** .000	.307** .000
7	.623** .000	.173** .001	.247** .000	.141** .006	.091 .076	.432** .000	1	.330** .000	.441** .000	.571** .000	.601** .000	.447** .000	.404** .000	.431** .000
8	.411** .000	-.007 .892	.144** .005	-.024 .639	-.046 .367	.293** .000	.330** .000	1	.240** .000	.278** .000	.256** .000	.215** .000	.307** .000	.170** .001
9	.641** .000	.015 .773	.139** .007	.006 .901	.095 .063	.765** .000	.441** .000	.240** .000	1	.470** .000	.675** .000	.390** .000	.338** .000	.292** .000
10	.611** .000	.108* .036	.263** .000	.089 .082	.002 .973	.435** .000	.571** .000	.278** .000	.470** .000	1	.616** .000	.367** .000	.359** .000	.308** .000
11	.671** .000	-.097 .059	.185** .000	.082 .112	.015 .772	.572** .000	.601** .000	.256** .000	.675** .000	.616** .000	1	.478** .000	.336** .000	.332** .000
12	.459** .000	.083 .107	.132* .010	.251** .000	-.018 .724	.437** .000	.447** .000	.215** .000	.390** .000	.367** .000	.478** .000	1	.288** .000	.331** .000
13	.398** .000	.076 .139	.189** .000	.090 .080	.429** .000	.437** .000	.404** .000	.307** .000	.338** .000	.359** .000	.336** .000	.288** .000	1	.168** .001
14	.380** .000	.217** .000	.179** .000	.115* .024	.125* .015	.307** .000	.431** .000	.170** .001	.292** .000	.308** .000	.332** .000	.331** .000	.168** .001	1

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Description of Variables: 1= Per Capita Calorie Intake, 2= Age of Respondent, 3= Gender of Respondent, 4= Occupation, 5= Total Number of Family Members, 6= Total Aggregate Income, 7= Aggregate Human Capital, 8= Aggregate Natural Capital, 9= Aggregate Financial Capital, 10= Physical capital index, 11= Social Capital Index, 12= Total Land, 13= Expenditure on Food/Year, 14= Year of Schooling of housewife.

Factors Influence Future SLR Food Security in Study Area: Regression Results

Based on the correlation coefficient result presented in the table 9.6, total 13 variables are included in the linear regression model. It reveals that model for study area having 55.5% of total variance ($p<0.01$). Out of the 13 variables included in the regression model, eight are found having significant influence on per capita calorie consumption such as, age of respondents, gender of respondents, total land, aggregate human capital index, aggregate natural capital index, aggregate financial capital index, Physical capital index and social capital index.

Age of respondents appears as a significant predictor of future disaster household food security in the study area that explained 14.1% ($p<0.05$) of total variance. Hence, level of age leads better knowledge and management of available household resources which leads to the increasing impact on calorie intake within the sample households. Likewise, gender of the household head is found having significant positive impact on future SLR household food security in the coastal zone that explained 8.0 % ($p<0.05$) of total variance. Male headed households are relatively well-off then female headed. Household head is the primary responsible person to arrange food and care of individual family members and provide buffer against any exogenous force.

Amount of land is positively related with potential SLR induced food insecurity that explained 8.5% ($p<0.05$) of total variance. Coastal zone is agro-based, hence households possess large amount of land are more food secure in post-SLR situation. Similarly, most of the rural households spend their major share (45%) of income to purchase food items. By far food was the biggest item of expenditure for all sampled households.

The assets are the building blocks of livelihoods. A range of assets are needed to achieve positive livelihood outcomes such as food security. In the present model human and natural capital appear as significant positive predictors of household's post-disaster calorie availability in study area. Human, natural capitals, financial, physical and social explains 14.7% ($p<0.05$), 15.4% ($p<0.01$), 27.7% ($p<0.01$), 15.5% ($p<0.01$) and 14.7 % ($p<0.01$) of total variance respectively.

Higher amount of capital index value represents more assets of the households. The access of poor people to any types of assets is likely to be limited. Most of the research indicate that poorest having lack of assets and are the worst victims of disaster.[16]

Households with more capitals have greater range of choices and scope to invest one type of capital to achieve another.[17] Hence, households having more assets can readily help themselves by converting one type of assets to other and become relatively more secure for any disaster.[18] Hence, ability to move out from food insecurity depends on the combination of access to various types of livelihood assets.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.814[a]	.663	.651	291.75658

Predictors: (Constant), Expenditure on Food/ Year, Age of Respondent, Occupation, Gender of Respondent, Aggregate Natural Capital, Year of Schooling of housewife, Aggregate Financial Capital, Total Number of Family Members, Total Land, Physical capital index, Aggregate Human Capital, Social Capital Index, Total Aggregate Income of Household.

ANOVAa

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	61228559.589	12	4709889.199	55.331	.000[b]
	Residual	31154615.965	368	85121.902		
	Total	92383175.553	380			

a. Dependent Variable: Per capita Kcal intake

b. Predictors: (Constant), Expenditure on Food/Year, Age of Respondent, Occupation, Gender of Respondent, Aggregate Natural Capital, Year of Schooling of housewife, Aggregate Financial Capital, Total Number of Family Members, Total Land, Physical capital index, Aggregate Human Capital, Social Capital Index, Total Aggregate Income of Households.

[16] Bhagirath Behera, and Stefanie Engel, "Institutional analysis of evolution of joint forest management in India: A new institutional economics approach," *Forest Policy and Economics* 8, no. 4 (2006): 351.

[17] Emery, Mary Emery, and Cornelia Flora, "Spiraling-up: Mapping community transformation with community capitals framework," *Community development* 37, no. 1 (2006): 21.

[18] Hartwig De Haen, and Günter Hemrich, "The economics of natural disasters: implications and challenges for food security," *Agricultural economics* 37, no. s1 (2007): 25.

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1248.505	120.416		10.368	.000
	Age of Respondent	-4.495	1.040	-.141	-4.322	.000
	Gender of Respondent	131.790	53.095	.080	2.482	.014
	Occupation	18.901	33.730	.018	.560	.576
	Year of Schooling of housewife	2.599	6.609	.014	.393	.694
	Total Number of Family Members	-8.002	12.211	-.023	-.655	.513
	Total Land	20.198	9.102	.085	2.219	.027
	Aggregate Human Capital	493.299	149.290	.147	3.304	.001
	Aggregate Natural Capital	804.686	177.016	.154	4.546	.000
	Aggregate Financial Capital	1067.769	206.004	.277	5.183	.000
	Physical capital index	487.279	131.425	.155	3.708	.000
	Social Capital Index	551.184	186.944	.147	2.948	.003
	Expenditure on Food/ Year	.003	.002	.053	1.317	.189

a. Dependent Variable: Per Capita Kcal intake

9.6 Household Nutritional Security: Nutritional Status of Women at Reproductive Age and Under Five Years of Children

To determine livelihood security outcome of household it is essential to measure nutritional security. It is very much associated with food security, especially food utilization. The conventional way of measuring household nutritional security is measuring health and nutritional status of reproductive women and children of under five years of age. In fact, these two are most vulnerable population groups; any types of malnutrition may cause severe adverse impacts on child-bearing women and children. The body mass index of reproductive women is measured to assess the nutritional status. This is a robust indicator and widely used in the nutritional studies to measure nutritional status of women between the age of 15 to 50 years. Height and body weight is recorded to measure the body mass index that represents the underweight (malnutrition) or overweight of women. Likewise, stunting and wasting among children between the ages of 6 months to 59 months are widely used indicators of measuring malnutrition status of children. Children fall within the age of 6-59 months are weighed and height is measured. Age, height and weight is used to calculate the ratio of height to age (stunting) and weight to height (wasting) comparing with the height and weight of reference population.

9.6.1 Body Mass Index for Women of Reproductive Age

The body mass index (BMI) is a numerical measure of body mass based on weight and height of a person. Calculation of body mass index was invented by Adolphe Quetelet during 1830 to 1850. Therefore, it is also termed as Quetelet index. BMI does not calculate actual body fat, but it approximates a person's healthy body weight based on height. Due to the simplicity in measurement and calculation, it is widely used as a diagnostic tool for identifying whether a person is underweight, overweight or obese. Calculation of body mass index includes body weight of individual divided by the square of individual's height. This formula is universally used in medical science to calculate a unit of measure of Kilogram/Meter Square.

$$\textit{Body Mass Index (BMI)} = \textit{Body Mass (in Kg)} / \{\textit{Height (in meter)}\}^2$$

The BMI is frequently used to assess the deviation of individual's body weight from the normal or desirable with regard to height. The recommended distinctions or cut off points along the linear scale may vary over time and country. Therefore, making universal global longitudinal survey for BMI is problematic. Considering this limitation, World Health Organization's (WHO) standard is used to demarcate the categories of underweight, normal weight, over weight and obese. According to WHO a BMI of less than 18.5 is under weight, BMI 18.5 to 25 is normal weight, BMI greater than 25 is overweight, and above 30 is regarded as obese.

According to this scale the present study finds that 9.7%, 19.4%, 19.3%, 8.2%, 4.8%, and 26.1% of sampled women in reproductive age were underweight in Munshigonj, Gabura, Lalua, Nilgonj, Khurushkul and Bharuakhali respectively. It reveals relatively more number of women fall in the underweight category in Gabura, Lalua and Bharuakhali union, which reveals relatively higher level of nutritional insecurity of both the villages. Future adverse situation will obstruct the nutritional security of these areas.

However, this finding demonstrates relatively better picture than UNICEF study, where the organization found more than 50% of women of reproductive age in Bangladesh is underweight; means having BMI of less than 18.5.[19]

About 81.9%, 70.8%, 66.7%, 81.6%, 95.2% and 73.9% of women in reproductive age is found having normal weight category in Munshigonj, Gabura, Lalua. Nilgonj, Khurushkul and Bharuakhali respectively. However, percentage of women in this category does not vary significantly across the villages. On the other hand, women in reproductive age fall in overweight category are fewer in number in each union respectively.

[19] UNICEF, Child and Maternal Nutrition in Bangladesh, retrieved from http://www.unicef.org/ Bangladesh/ Child_and_Maternal_Nutrition.pdf, (Accessed on 3 November 2016).

Percentage of women having BMI of more than 30 (obese) is mostly across the Nilgonj Union (4.1%). This reveals that obese is not a severe problem in rural Bangladesh, rather underweight of reproductive women is a great concern. Underweight of reproductive women reveals prevalence of malnutrition. This is a particular concern of this population group because of malnutrition of women are not only at health risk but their offspring are at greater risk of mortality due to lower level of maternal BMI. Low maternal BMI is linked with certain severe adverse pregnancy outcomes such as premature birth and low birth weight. Moreover, if child survives health risk of such child remain persistence in later part of the life such as asthma and neuro-developmental delays etc.[20]

Table 9.7: Body Mass Index of Reproductive Women between 15-59 Years

Status		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Underweight	n	7	14	11	4	4	12	52
	%	9.7%	19.4%	19.3%	8.2%	4.8%	26.1%	13.7%
Normal weight	n	59	51	38	40	80	34	302
	%	81.9%	70.8%	66.7%	81.6%	95.2%	73.9%	79.5%
Overweight	n	6	7	8	3	0	0	24
	%	8.3%	9.7%	14.0%	6.1%	0.0%	0.0%	6.3%
Obese	n	0	0	0	2	0	0	2
	%	0.0%	0.0%	0.0%	4.1%	0.0%	0.0%	0.5%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Likelihood Ratio	Value=50.352, df=15, p=.000							

Source: Questionnaire Survey, June-October, 2016

9.6.2 Weight for Height of Under Five Years of Children

Livelihood security can be assessed by measuring the child nutrition of the household of the region. Malnutrition of children can be assessed by comparing the weight of a malnourished child according to his/her height with the weight of a well-nourished child of the same height. This method is considered as a best way of assessing acute malnutrition considering that there is no oedema present. A normal and well-nourished child of a certain height can be expected to have a certain body weight. A series of such 'normal'

[20] Alayne G. Ronnenberg, Xiaobin Wang, Houxun Xing, Chanzhong Chen, Dafang Chen, Wenwei Guang, Aiqun Guang, Lihua Wang, Louise Ryan, and Xiping Xu, "Low Preconception Body Mass Index is Associated with Birth Outcome In A Prospective Cohort of Chinese Women," *The Journal of Nutrition* 133, no. 11 (2003): 3451.

weight has been calculated and they are considered to be 100% of standard weight for height and used as a reference weight. Any child having oedema is considered as malnourished irrespective of body weight. A series of these ‘normal’s’ has been calculated and they are considered to be 100% of standard weight for height. The percentage weight for height is calculated by using following formula.

*Percent Weight-for-Height = Child’s Weight*100/Reference Weight for Same Sex and Height.* [21]

The present study finds that 7.7%, 12.5%, 55.6%, 57.1%, 27.8%, 37.5% and 32.9% of children are malnourished or underweight (wasted) according to weight for height measurement in Munshigonj, Gabura, Lalua, Nilgonj, Khurushkul and Bharuakhali union respectively. However, these figures are relatively higher than the earlier findings of Bangladesh which unveils the overall 17.4% of children in Bangladesh are wasted. [22]

Nutritional status of children shows lesser degree of improvement in Bangladesh (UNDP, 2006), but still significantly higher number of children are wasted in coastal zone of Bangladesh.

On the other hand, 69.2%, 87.5%, 44.4%, 42.9%, 61.1% and 62.5% of sampled children in Munshigonj, Gabura, Lalua, Nilgonj, Khurushkul and Bharuakhali union respectively are found adequately nourished. The present study also finds that 0.0%, 0.0%, 0.0%, 4.1%, 0.0% and 0.0% of sampled children are overweight category in Munshigonj, Gabura, Lalua, Nilgonj, Khurushkul and Bharuakhali union respectively. However, wasting is severe problem in all six unions, but situation is relatively better in some places in coastal area. However, in general significant difference exists among the areas in terms of weight for height of children and average weight for height percentage significantly varied across the villages.

[21] Available at https://www.cdc.gov/nccdphp/dnpa/growthcharts/training/modules/module1/text/module1print.pdf (accessed on 11 March 2016).

[22] National Institute Of Population Research and Training. *Bangladesh Demographic and Health Survey 2011*. Mitra and Associates Dhaka, Bangladesh (Dhaka: April 2012), 32.

Table 9.8: Percent Weight for Height for Under Five Years of Children

Child Weight For Height		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Malnourished	n	1	1	5	8	5	3	23
	%	7.7%	12.5%	55.6%	57.1%	27.8%	37.5%	32.9%
Adequately nourished	n	9	7	4	6	11	5	42
	%	69.2%	87.5%	44.4%	42.9%	61.1%	62.5%	60.0%
Over weight	n	3	0	0	0	2	0	5
	%	23.1%	0.0%	0.0%	0.0%	11.1%	0.0%	7.1%
Total	n	13	8	9	14	18	8	70
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Likelihood Ratio	Value =19.418, df=10, **p=** .000							

Source: Questionnaire Survey, June-October, 2016

9.6.3 Weight-for-Age of Under Five Children

Weight for age is also used as an indicator of child malnutrition. In the initial phase of a disaster, weight for age is not considered as effective as weight for height. Main reason for this is linked with difficulties in assessing child age accurately. In Bangladesh context adults even rarely know accurate birth dates. Weight for age is calculated by expressing the child's weight as a percentage of a reference weight for a child of the same age and sex. The formula is as follows:

*Percent Weight-for-Age = Child's Weight for Age*100/Reference Weight-for Age*

The present study finds that 30.8%, 37.5%, 22.2%, 28.6%, 16.7% and 12.5% of children in Munshigonj, Gabura, Lalua, Nilgonj, Khurushkul and Bharuakhali union respectively fall in underweight category in terms of weight for age of under five children in compare with reference child population of Bangladesh.

This reveals relatively slightly higher number of underweight children are found in Gabura, Lalua and Khurushkul union. According to Bangladesh Demographic and Health Survey (2011) approximately 41% of children under five years of age are underweight. This findings suggests that percentage of underweight children are relatively higher in Gabura and Lalua Union, while Munshigonj and Nilgonj relatively are better off in terms of nutritional situation, which is less than national average. Likewise, 46.2%, 50.0%, 55.6%, 64.3%, 66.7%, 87.5% and 61.4% of children fall in Munshigonj, Gabura, Lalua, Nilgonj, Khurushkul and Bharuakhali union respectively for the adequately nourished category. While 23.1%, 12.5%, 22.2%, 7.1%, 16.7% and 0.0% of children in Munshigonj, Gabura, Lalua, Nilgonj, Khurushkul and Bharuakhali union are overweight in terms of weight for age of children.

However, based on the findings Munshigonj, Nilgonj and Khurushkul demonstrate relatively better off nutritional status than rest three unions. Average weight for age for under five years of children significantly varies across the villages (table 9.9). However, weight for age does not vary significantly among different livelihood groups.

Table 9.9: Weight-for-Age of Under Five Children

Status		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Under weight	N	4	3	2	4	3	1	17
	%	30.8%	37.5%	22.2%	28.6%	16.7%	12.5%	24.3%
Adequately Nourished	n	6	4	5	9	12	7	43
	%	46.2%	50.0%	55.6%	64.3%	66.7%	87.5%	61.4%
Over Weight	n	3	1	2	1	3	0	10
	%	23.1%	12.5%	22.2%	7.1%	16.7%	0.0%	14.3%
Total	n	13	8	9	14	18	8	70
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Likelihood Ratio	Value=20.046, df=5, p=.000							

Source: Questionnaire Survey, June-October, 2016

9.6.4 Height-for-Age of Under Five Children

Percentage of height for age of under five children against the reference height for age of children is a measure of chronic malnutrition. However, this may not useful in planning for short term emergency situation. This is the height of a child expressed as a percentage of, or as a standard deviation from the height of a reference child of the same age and sex. Age must be known to the nearest month. Stunting (short for age) is defined as a height-for-age of less than 90% of the reference median. The calculation is as follows.

*Percent Height-for-Age = Child's Height-for-Age*100/Reference Height-for-Age*

The present study finds that 38.5%, 75.0%, 77.8%, 13.3%, 22.2% and 62.5% of children are stunted in Munshigonj, Gabura, Lalua, Nilgonj, Khurushkul and Bharuakhali union respectively. This reveals that significantly higher number of children in all study areas is stunted, and which is higher than the national average of 40%. On the other hand, 61.5%, 25.0%, 22.2%, 86.7%, 77.8% and 37.5% of children in Munshigonj, Gabura, Lalua, Nilgonj, Khurushkul and Bharuakhali union respectively are normal according to the height for age. However, such findings reveal relatively better of nutritional situation of Munshigonj, Nilgonj, and Khurushkul than Gabura, Lalua and Bharuakhali union. Average height for age for under five years of children significantly varies across the unions (table 9.10).

Table 9.10: Height-for-Age of Under Five Children

Child Height for age		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Stunted	n	5	6	7	2	4	5	29
	%	38.5%	75.0%	77.8%	13.3%	22.2%	62.5%	40.8%
Normal	n	8	2	2	13	14	3	42
	%	61.5%	25.0%	22.2%	86.7%	77.8%	37.5%	59.2%
Total	n	13	8	9	15	18	8	71
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Likelihood Ratio	Value =18.743, df=5, p= .003							

Source: Questionnaire Survey, June-October, 2016

9.7 Economic Security of Household

There is a close relationship between livelihood security and economic security. However, it is very difficult to measure economic status of a household directly through any single indicator. Income of a household is often derived from various formal and informal sources, and labor in many cases compensated by non-monetary units for example food. Similarly, wage labor itself is irregular and periodic, and sometime difficult to remember and measure. Similarly, income from agricultural production and fishing is difficult to put under any regular accounting process. Considering these difficulties of measuring household economic security, three approaches are addressed such as annual household income, value of key household assets, and savings and debt level of households.

9.7.1 Annual Household Income Flow

Annual income of household is a key measure of economic security. This indicator is used to measure household economic security with a common assumption of households having more number of annual cash income flows are secured economically. There are various reasons for not actual estimating of overall income such as difficulties in recall and under reporting of income etc. However, such errors are randomly distributed across the samples. Therefore, small changes in this indicator over time do not reflect the significant change in the economic status of household. This represents the aggregate income of a household. One person can be engaged in several income earning activities, thus annual value of each sector are computed together to get individual's annual income. Annual cash income earned by each member of a household are computed together to get the aggregate annual household income.

The present study finds that 37.5%, 50.0%, 35.1%, 28.6%, 25.0% and 63.0% of respondents in Munshigonj, Gabura, Lalua, Nilgonj, Khurushkul and Bharuakhali union respectively fall in lower income group (<BDT 45000). Bharuakhali, Gabura and Lalua hold the higher portion of lower income. On the other hand 44.4%, 37.5%, 64.9%, 67.3%, 42.9% and 37.5% fall in middle income group (BDT 45000-90000). Higher income groups are found in mainly in Khurushkul (32.1%), and Munshigonj (18.1%). Moreover, present findings reveal that there is significant difference exists among the unions regarding income per year. The reason is that the income options are higher in Munshigonj, Nilgonj and Khurushkul than Gabura, Lalua and Bharuakhali.

Table 9.11: Annual Income of the Household by Village, Gender, Education and Livelihood Groups

Income Level (BDT)		Study Villages						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
<45000	n	27	36	20	14	21	29	147
	%	37.5%	50.0%	35.1%	28.6%	25.0%	63.0%	38.7%
45000-90000	n	32	27	37	33	36	17	182
	%	44.4%	37.5%	64.9%	67.3%	42.9%	37.0%	47.9%
>90000	n	13	9	0	2	27	0	51
	%	18.1%	12.5%	0.0%	4.1%	32.1%	0.0%	13.4%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Likelihood Ratio	Value =73.413, df=10, p= .000							

Source: Questionnaire Survey, June-October, 2016

The present study finds that according to livelihood group annual income varies 51.7%, 26.5%, 21.85% annual income holder are in Farmer, Fisher and wage labor group (BDT <45000) respectively. 39.6%, 29.7% and 30.8% fall in Farmer, Fisher and wage labor group (BDT 45000-90000) respectively. 74.5%, 17.6%, 7.8% % fall in Farmer, Fisher and wage labor group (BDT >90000) respectively. This finding reveals that income from agriculture is higher. Moreover, significant difference exists among the unions regarding income by livelihood groups (table 9.12).

Table 9.12: Annual Income of the Household by Livelihood Groups

Livelihood Groups		Total Income (BDT)			Total
		<45000	45000-90000	>90000	
Farmer	n	76	72	38	186
	%	51.7%	39.6%	74.5%	48.9%
Fisher	n	39	54	9	102
	%	26.5%	29.7%	17.6%	26.8%
Wage labor	n	32	56	4	92
	%	21.8%	30.8%	7.8%	24.2%
Total	n	147	182	51	380
	%	100.0%	100.0%	100.0%	100.0%
Chi-square	Value=21.705, df=4, p=.000				

Source: Questionnaire Survey, June-October, 2016

This study finds that annual income varies by education group of the study area. The study area comprises of mainly farmer, fisher and wage labor group who mainly fall in illiterate or minimum education group like illiterate and can read and write education group. 44.2%, 42.2%, 4.1%, 6.8% and 2.7% fall in Illiterate, Can read and write, Primary School, Secondary school and College lower income (BDT<45000) group. On the other hand 48.4%, 35.7%, 8.8%, 4.9%, 2.2% and 2.2% fall in Illiterate, Can read and write, Primary School, Secondary school and College middle income (BDT<45000) group. In contrast, 15.7%, 54.9%, 19.6%, 5.9% and 3.9% fall in Illiterate, Can read and write, Primary School, Secondary school and College in higher income (BDT>90000) group.

Table 9.13: Annual Income of the Household by Education Groups

Education Groups		Total Income (BDT)			Total
		<45000	45000-90000	>90000	
Illiterate	n	65	88	8	161
	%	44.2%	48.4%	15.7%	42.4%
Can read & write	n	62	65	28	155
	%	42.2%	35.7%	54.9%	40.8%
Primary School	n	6	16	10	32
	%	4.1%	8.8%	19.6%	8.4%
Secondary school	n	10	9	3	22
	%	6.8%	4.9%	5.9%	5.8%
College	n	4	4	2	10
	%	2.7%	2.2%	3.9%	2.6%
Total	n	147	182	51	380
	%	100.0%	100.0%	100.0%	100.0%
Likelihood Ratio	Value=26.913, df=8, p=.001				

Source: Questionnaire Survey, June-October, 2016

Accordingly, this study finds annual income of the household varies considering the gender of the household. It reveals that income level BDT<45000 holds 85.0% for male and 15.0% for female headed household. Income level BDT 45000- 90000 holds 87.0% for male and 12.6% for female headed household. BDT>90000 holds 80.4% for male and 19.6% for female headed household. There is significant difference exists regarding the income according to gender of household.

Table 9.14: Annual Income of the Household by Gender Groups

Gender Groups		Total Income (BDT)			Total
		<45000	45000-90000	>90000	
Male	n	125	159	41	325
	%	85.0%	87.4%	80.4%	85.5%
Female	n	22	23	10	55
	%	15.0%	12.6%	19.6%	14.5%
Total	n	147	182	51	380
	%	100.0%	100.0%	100.0%	100.0%
Chi-square	Value=1.611, df=2, p=.007				

Source: Questionnaire Survey, June-October, 2016

9.7.2 Household Annual Expenditure

It is very difficult to gather accurate figure of income of a household. Therefore, household consumption expenditures are regarded as more reliable proxy measures of income, because household expenditures are less variable. It is found in present study that 37.5%, 50.0%, 49.1%, 27.9%, 33.3% and 63.3% of the respondents fall in the category of yearly expenditure of BDT < 45000 respondents in Munshigonj, Gabura, Lalua, Nilgonj, Khurushkul and Bharuakhali union respectively. In Munshigonj, Gabura, Lalua, Nilgonj, Khurushkul and Bharuakhali union respectively 27.8%, 6.9%, 28.1%, 30.2%, 15.5% and 13.0% of the respondents fall in the category of yearly expenditure of BDT 45000-60000. More than BDT 60000 per year expenditure is higher in Munshigonj, Nilgonj and Bharuakhali union. It also reveals that there is significant difference exists in yearly expenditure among the study unions (Likelihood ratio=78.242, df=15, p=.000). In this context location like Gabura, Bharuakhali are vulnerable to any future climatic event (table 9.15). It is found in the study that expenditure is higher in Munshigonj and Nilgonj because of the higher expenditure in different categories such as education, food, communication, medical expenditure etc.

Table 9.15: Total Expenditure of the Household by Different Study Area

Level of Expenditure (BDT)		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
<45000	n	27	36	28	12	28	29	160
	%	37.5%	50.0%	49.1%	27.9%	33.3%	63.0%	42.8%
45000-60000	n	20	5	16	13	13	6	73
	%	27.8%	6.9%	28.1%	30.2%	15.5%	13.0%	19.5%
60000-90000	n	11	18	13	18	36	11	107
	%	15.3%	25.0%	22.8%	41.9%	42.9%	23.9%	27.6%
>90000	n	14	13	0	6	7	0	40
	%	19.4%	18.1%	0.0%	12.24%	8.3%	0.0%	10.1%
Total	n	72	72	57	49	84	46	380
	%	19.3%	19.3%	15.2%	11.5%	22.5%	12.3%	100.0%
Likelihood Ratio	Value =78.242, df=15, p= .000							

Source: Questionnaire Survey, June-October, 2016

9.7.3 Household Debt Level: An Alternative of Economic Security

For determining economic security household debt level is a key indicator. Household's level of debt may represent economic status of a household, if such debt is invested on various rural infrastructures such as buying of land, agriculture or fishing accessories etc. However, if such debt is not invested in productive way might create extreme financial burden and a state of dependency.

The present study finds that the household of the study area take loan from different sources like Mohajon/Money lenders, NGO, Friends, Relatives, and Grameen bank etc. NGO and Relatives hold the highest portion about providing the credits. 13.55%, 11.1%, 33.3%, 25.0%, 10.9% and 0.0% get loan from Mohajon/Money Lender of Munshigonj, Gabura, Lalua, Nilgonj, Khurushkul and Bharuakhali union respectively. 42.3%, 50.0%, 12.5%, 45.05, 65.2% and 36.7% of Munshigonj, Gabura, Lalua, Nilgonj, Khurushkul and Bharuakhali union respectively take from NGO's 28.85, 30.6%, 0.0%, 0.0%, 23.9%, and 43.35% of Munshigonj, Gabura, Lalua, Nilgonj, Khurushkul and Bharuakhali union respectively from friends and relatives. 15.4%, 8.3%, 54.2%, 30.0%, 0.0% and 20.05 of Munshigonj, Gabura, Lalua, Nilgonj, Khurushkul and Bharuakhali union respectively from Grameen Bank. Significant difference exist regarding borrowing loan among the unions (table 9.16).

Money lenders are the important loan providers in agro-based coastal area. On the other hand, arotdars played a vital role among fishing communities. Moreover, some households in study area had borrowed money from friends and relatives. Borrowing money from friends and relatives are most cases without any interest. From FGD during field survey it reveals that Government banks had limited coverage of distributing loan in all study areas. The households had received loans from government banks are most cases local elite people. Government banks are relatively less accessible by local common people. Therefore, most of the people rely on NGOs and/or mahajan and arotdars. The present study finds that households take credit from multiple sources, household usually borrow money from one source to deposit installments for others, and finally end up with revolving debt. Productive utilization of debt brings strong economic base to combat any potential adversity.

Table 9.16: Sources of Household Debt by Village

Sources of Credit		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Mohajon/Money Lender	n	7	4	8	5	5	0	29
	%	13.5%	11.1%	33.3%	25.0%	10.9%	0.0%	13.9%
NGO's	n	22	18	3	9	30	11	93
	%	42.3%	50.0%	12.5%	45.0%	65.2%	36.7%	44.7%
Friends/Relatives	n	15	11	0	0	11	13	50
	%	28.8%	30.6%	0.0%	0.0%	23.9%	43.3%	24.0%
Grameen Bank	n	8	3	13	6	0	6	36
	%	15.4%	8.3%	54.2%	30.0%	0.0%	20.0%	17.3%
Total	n	52	36	24	20	46	30	208
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Likelihood Ratio	Value =85.019, df=15, p= .000							

Source: Questionnaire Survey, June-October, 2016

It is found in the present study that the respondents of the study area borrow money in terms of different needs. In different regions 88.0% respondents borrow money within BDT 10000. It is found that 88.5%, 91.7%, 87.5%, 100.0%, 71.7% and 100.00% borrow money within the mentioned limit in Munshigonj, Gabura, Lalua, Nilgonj, Khurushkul and Bharuakhali union respectively (table 9.17). Significant difference exists among the unions regarding borrowing money. As regard information procured through FGD it is found that large number of respondents in all study areas borrow money for emergency food consumption. This group belongs to the lower income category; usually borrow money from NGOs and relatives to meet the lean period emergency food consumption. Another significant part of respondents borrow to invest money for buying fishing accessories such as boat, nets etc. This needs a big amount of money, most cases borrowed from NGOs and arotdars. Similarly, few respondents were found to invest borrowed money for business purposes.

Similarly, from FGD it is found that households borrow to repay previous loan. Similarly, other important areas of investing loan are buying productive assets and land. Investing loan for fishery project is mostly found in Khurushkul and Gabura. Use of loans for such purposes unveils borrowing for productive purposes. Therefore, access to credit and use of such credit for productive purposes demonstrates relatively higher level of economic security of households of Munshigonj, Nilgonj and Khurushkul but opposite scenario is found in Gabura, Lalua and Bharuakhali union. Even though few households borrow money for emergency food consumption purposes are in the bottom of the income category. However, such households are unlikely to recover from shocks and secure livelihoods. In general, households investing borrowed money for productive purposes are economically more secured and mostly found in Munshigonj, Nilgonj and Khurushkul union. These locations are identified as less vulnerable for future adversity as compared with other three unions like Gabura, Lalua and Bharuakhali.

Table 9.17: Household's Amount of Borrowing by Village

Total Amount of Loan Category (BDT)		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
1-10000	n	46	33	21	20	33	30	183
	%	88.5%	91.7%	87.5%	100.0%	71.7%	100.0%	88.0%
10000-20000	n	4	3	3	0	13	0	23
	%	7.7%	8.3%	12.5%	0.0%	28.3%	0.0%	11.1%
20000-30000	n	2	0	0	0	0	0	2
	%	3.8%	0.0%	0.0%	0.0%	0.0%	0.0%	1.0%
Total	n	52	36	24	20	46	30	208
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Likelihood Ratio	Value =28.393, df=10, p= .002							

Source: Questionnaire Survey, June-October, 2016

9.7.4 Household Savings Level

Household's level of savings is an effective indicator of economic security. This indicator finds the resiliency to external shocks and stresses of household. Household having higher level of savings demonstrate better level of resiliency and a higher level of economic security. Table 9.18 shows that 25.0% of the respondents have savings 75.0% of them don't have savings. The present study finds that Khurushkul (58.3%), Lalua (21.1%), Nilgonj (20.4%) unions comparatively hold higher level of savings than other three unions (table 9.18). This reveals significant difference among the unions in terms of household savings. Khurushkul demonstrates relatively well-off position than other unions because divrse sources of income.

Table 9.18: Distribution of Households Based on Savings

Saving Status		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Yes	n	9	6	12	10	49	9	95
	%	12.5%	8.3%	21.1%	20.4%	58.3%	19.6%	25.0%
No	n	63	66	45	39	35	37	285
	%	87.5%	91.7%	78.9%	79.6%	41.7%	80.4%	75.0%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Chi-square	Value=68.194, df=5, p=.000							

Source: Questionnaire Survey, June-October, 2016

The present study also finds that majority of the households hold saving BDT 1-10000 groups. They are Munshigonj, Gabura, Lalua, Nilgonj, Khurushkul and Bharuakhali union for 77.8%, 100.0%, 100.0%, 100.0%, 100.0% and 77.8% respectively. Few households have savings in the group of BDT 10000- 20000 like Nilgonj (30.0%), Khurushkul (38.8%) and Bharuakhali (22.2%). Very few households in Munshigonj have saving group for more than BDT 20000. Significant difference exists among the households regarding their savings (table 9.19) as the income sources of the respondents of Khurushkul and Nilgonj are higher than other unions.

Table 9.19: Distribution of Households Based on Savings category

Savings category (BDT)		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
1-10000	n	7	6	12	7	30	7	69
	%	77.8%	100.0%	100.0%	70.0%	61.2%	77.8%	72.6%
10000-20000	n	0	0	0	3	19	2	24
	%	0.0%	0.0%	0.0%	30.0%	38.8%	22.2%	25.3%
>20000	n	2	0	0	0	0	0	2
	%	22.2%	0.0%	0.0%	0.0%	0.0%	0.0%	2.1%
Total	n	9	6	12	10	49	9	95
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Likelihood Ratio	Value =28.886, df=10, p= .001							

Source: Questionnaire Survey, June-October, 2016

On the other hand, among the livelihood groups' average savings of fisher is significantly higher than farmer and wage laborer. Such finding has a severe implication that income is not evenly distributed across the villages and among the livelihood groups. Fishermen those usually invest for relatively bigger boats and nets requires big amount of money. Therefore, fisher livelihood group reveals higher amount of savings. However, in general majority of the fishermen reveals lower amount of savings.

This reveals significant income inequality among the households of the study area. Similarly, the households having lower amount of savings are mostly among the members of NGOs. The members of NGOs are forced to save some amount of as deposit money, but not accessible during needs. In fact, NGOs do not allow members to withdraw the saving money when they are in need.

Household usually spend savings for some common purposes such as agricultural accessories and inputs, reconstruction of houses, loan repayment, health care, marriage ceremony, buying food, investing in business, buying livestock and poultry, and clothes.

Use of savings for agriculture is higher in Munshigonj union, while investment of savings for fishing accessories is higher in Khurushkul and Lalua union. Use of savings for health care is mostly common among all six unions. On the other hand, relatively poorer households were found to spend savings for food consumption especially in Bharuakhali union. However, in general households having stable income source, headed by male, located in Munshigonj and Nilgonj, literate household head, and having involvement with NGOs unveils a greater rate of possessing savings.

9.8 Household's Shelter, Water and Sanitation Security

In the present study to measure shelter, water and sanitation security few selected indicators are used. These indicators include quality of housing, household's having access to toilet and drinking water facility.

9.8.1 Shelter Security

Quality of housing is measured by few proxy indicators, such as type of materials used for roof, wall and floor. However, especially roofing material of house alone also reflects standard of housing in rural Bangladesh context. Selection of these housing materials depends on the cultural and socio-economic condition of households such as income, family size, and cultural practices etc. Likewise, selection of permanent roofing material for example corrugated iron (CI) sheets represents relatively better standard of housing than the houses use straw/grass as roofing materials. Similarly, all three study villages are out of the service of electricity. Therefore, households having solar panel for electricity reflects relatively better standard of housing.

The present study finds that the majority respondents use tin as roof materials in Munshigonj (77.8%), Nilgonj (87.8%) and Khurushkul (72.6%) and it finds that majority of the respondents in Munshigonj (58.3%), Nilgonj (79.6%) and Khurushkul (63.1%) had used CI sheets as wall materials for housing (Appendix- table 3, 4, 5).

Similarly, use of wall materials for housing significantly varies among the villages. CI sheet is more preferred wall material in Munshigonj and Khurushkul union. Straw is widely used wall material in Lalua and Gabura union. Few respondents had used wood and bamboo as wall materials, however most of them were in Gabura. In rural Bangladesh context floor of the house are prepared by mud on elevated earthen ground. In few cases roof and walls are constructed by CI sheets and floor is prepared by bricks and cements. Such type of houses reflects better standard of housing in rural Bangladesh context.

Other proxy indicators such as number of room in a house, size of living room, and electricity connection in the house are also used in the present study to measure standard of housing. It reveals that majority of the households in all areas had a single room in their house. It is found in the study areas that 31.9%, 45.8%, 43.9%, 36.7%, 25.0% and 58.7% of the respondents in Munshigonj, Gabura, Lalua, Nilgonj, Khurushkul and Bharuakhali union respectively hold single room for living. It reveals that the respondents of Gabura, Lalua and Bharuakhali hold maximum number single room for living. On the other hand 62.5%, 51.4%, 56.1%, 59.2%, 54.8% and 30.4% of the respondents in Munshigonj, Gabura, Lalua, Nilgonj, Khurushkul and Bharuakhali union respectively hold double room for living. Here it reveals that Munshigonj, Nilgonj and Khurushkul unions slightly higher in terms of double living rooms than Gabura, Lalua and Bharuakhali unions. More than three rooms are higher in Munshigonj, Nilgonj and Khurushkul.

Therefore, the findings of the present study reveal that housing standard in terms of the number of living rooms of house is relatively better in Munshigonj, Nilgonj and Khurushkul than Gabura, Lalua and Bharuakhali unions.

Table 9.20: Number of Living Rooms in Housing Unit

Number of Living Rooms		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Single Room	n	23	33	25	18	21	27	147
	%	31.9%	45.8%	43.9%	36.7%	25.0%	58.7%	38.7%
Double room	n	45	37	32	29	46	14	203
	%	62.5%	51.4%	56.1%	59.2%	54.8%	30.4%	53.4%
>3 Rooms	n	4	2	0	2	17	5	30
	%	5.6%	2.8%	0.0%	4.1%	20.2%	10.9%	7.9%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Likelihood Ratio	Value =43.461, df=10, p= .001							

Source: Questionnaire Survey, June-October, 2016

Considering the building materials of the dwelling unit of the respondents it reveals that 37.4% of the total residence is safe and 62.6% are unsafe. Safe houses comparatively support livelihood security of vulnerable place especially coastal zone of Bangladesh. The overall findings indicate that location nearer to sea like Gabura, Lalua and Bharuakhali are comparatively more vulnerable to future adversity regarding the support of housing facilities (table 9.21).

Table 9.21: Safety Status of Housing Unit

Safety Status		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Safe	n	21	14	11	20	57	19	142
	%	29.2%	19.4%	19.3%	40.8%	67.9%	41.3%	37.4%
Unsafe	n	51	58	46	29	27	27	238
	%	70.8%	80.6%	80.7%	59.2%	32.1%	58.7%	62.6%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Chi-square	Value=53.821, df=5, p=.000							

Source: Questionnaire Survey, June-October, 2016

9.8.2 Electricity Connection in Housing Unit

Household electricity connection indicates the status of the respondents regarding economic and social level. Present study finds that more than 50% of the households are not under the coverage of electricity. Moreover, solar connection is higher than public electricity connections. In remote area that is Gabura, Lalua and Bharuakhali solar connections are found to be higher and Munshigonj, Nilgonj and Khurushkul comparatively public connections are higher. Less vulnerable areas are under the coverage of public electricity connection. But there is significant difference exists among the unions regarding the coverage of electricity connections.

Table 9.22: Electricity Connection in Housing Unit

Electricity Connection		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
None	n	39	62	36	20	27	26	210
	%	54.2%	86.1%	63.2%	40.8%	32.1%	56.5%	55.3%
Solar	n	18	10	18	19	42	16	123
	%	25.0%	13.9%	31.6%	38.8%	50.0%	34.8%	32.4%
Public	n	15	0	3	10	15	4	47
	%	20.8%	0.0%	5.3%	20.4%	17.9%	8.7%	12.4%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Likelihood Ratio	Value=61.143, df=10, p=.000							

Source: Questionnaire Survey, June-October, 2016

Therefore, findings of the present study unveils that households in Munshigonj, Nilgonj and Khurushkul are relatively secured in terms of housing standard than Gabura, Lalua and Bharuakhali. In Gabura and Lalua unions houses construction materials are mostly straw, thatch and bamboo etc. On the other hand, in Munshigonj, Nilgonj and Khurushkul main house construction material is CI sheet. Similarly, number of average living rooms and size of house is also relatively higher in Munshigonj, Nilgonj and Khurushkul village than Gabura, Lalua and Bharuakhali. Similarly, households belong to farmer livelihood group, and having higher income level had relatively better housing standard. Therefore, farming households and having higher income level irrespective of their village locations are relatively secured in terms of housing standard.

9.8.3 WATSAN Infrastructure: Access Sanitation and Drinking Water

This is another combined measurement extensively used by CARE international to presents household's access to sanitation and drinking water facilities. To assess household's sanitation situation it includes type of latrine available at household level, for example having no latrine, unsanitary and pit latrines etc. Similarly, to assess the drinking water facility it considers types of drinking water facilities available at household level, such as open water sources, community deep tube well or individual tube well. Simultaneously, this indicator also considers distance of drinking water source from household, and number of households shares the same water source. This reflects the accessibility of households to the drinking water sources. Finally, to assess the quality aspects of drinking water this includes arsenic contamination issues in drinking water. In recent time arsenic contamination in the ground water in rural Bangladesh is a vital issue for pure drinking water.

9.8.4 Household Sanitation Security

The present study finds that toilet facilities of the respondents are diverse among the unions of the study area. Majority of the respondents use sanitary/ring slab latrines (42.4%). It is also found that a major portion use hanging latrines (42.6%) and rest big portion use (11.8%) use open defection latrines. The percentage of surveyed households having toilet facility is higher quality in Munshigonj as Pit latrines (2.8%). Moreover, comparatively Sanitary/Ring slab latrines are found higher as 37.5%, 63.3%, 52.2% in Munshigonj, Nilgonj and Khurushkul respectively and lesser in Gabura and Lalua. Open defection and hanging toilet are higher in number in Gabura and Lalua as 58.3%, 78.9% respectively (Table 9.23). From this results it is clear that the people of Munshigonj. Nilgonj and Khurushkul have more hygienic sanitation facilities than Gabura, Lalua and Bharuakhali.

More number of households having toilet facility in Munshigonj, Nilgonj and Khurushkul reflect relatively better sanitation condition of the unions than other three unions. The main reasons of such differences in toilet facilities are closely linked to NGO activities in study village.

Many respondents mentioned that sanitation situation of the unions has significantly improved by the assistances of NGOs. Due to the proximity to the Upazila headquarter Munshigonj, Nilgonj and Bharuakhali receive various support services from government and NGOs. Therefore, they have relatively better sanitation. On the other hand, Gabura and Lalua having worse sanitation condition among six unions. Cyclone Sidr accompanied by severe storm surge significantly damaged the sanitation system these three unions. Therefore, the present finding reveals that Munshigonj, Nilgonj and Khurushkul are relatively secured in terms of sanitation facility than other three unions which keeps important role for livelihood security.

Table 9.23: Types of Sanitation Facility by Union

Types of Latrine		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Pit latrine	n	2	0	0	0	0	0	2
	%	2.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%
Sanitary/ring slab	n	27	14	12	31	53	24	161
	%	37.5%	19.4%	21.1%	63.3%	63.1%	52.2%	42.4%
Pucca (water sealed)	n	4	0	0	2	0	0	6
	%	5.6%	0.0%	0.0%	4.1%	0.0%	0.0%	1.6%
Pucca (un-hygienic)	n	2	0	0	0	0	0	2
	%	2.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%
Open defecation	n	7	16	0	2	16	4	45
	%	9.7%	22.2%	0.0%	4.1%	19.0%	8.7%	11.8%
Hanging	n	28	42	45	14	15	18	162
	%	38.9%	58.3%	78.9%	28.6%	17.9%	39.1%	42.6%
Others	n	2	0	0	0	0	0	2
	%	2.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Likelihood Ratio	Value =127.819, df=30, p= .000							

Source: Questionnaire Survey, June-October, 2016

9.8.5 Drinking Water Facility

In the coastal area of Bangladesh the use of drinking water from tube well is increasing. Almost all the households regardless of their village location, income level or livelihood group have access to tube well for drinking water. The present study finds that Nilgonj (71.4%) and Khurushkul (61.9%) union hold highest number of tube well for drinking water. In Lalua union the number is also higher as different NGOs and local government authority have set up tube well after cyclone of 2007. Most of the households use tube well water for drinking purpose.

Some households were found in interior unions use river and pond water for drinking purposes. The present study finds that 76.4%, 63.9%, 49.1%, 22.4%, 38.1% and 50.0% of respondents in Munshigonj, Gabura, Lalua, Nilgonj, Khurushkul and Bharuakhali respectively use pond as source of drinking water (table 9.24). However, it is not necessarily because of the inaccessibility to the tube wells, rather poor water quality of tube wells and arsenic contamination discouraged them to drink tube well water. These households were found consciously use river or pond water after boiling. In general tube wells were regarded as safe sources of drinking water in Bangladesh until the discovery of presence arsenic components in ground water in 1993. At present arsenic is identified in the tube wells of 59 districts out of 64 in the country with 21 million exposed and another 70 million people are at risk of arsenic contamination. All the tube wells of the country were not screened and extent of contamination is still unknown. [23]

Table 9.24: Distribution of Household by Drinking Water Facility

Sources of Drinking Water		Study Villages						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Tube well	n	10	10	29	35	52	23	159
	%	13.9%	13.9%	50.9%	71.4%	61.9%	50.0%	41.8%
Pond	n	55	46	28	11	32	23	195
	%	76.4%	63.9%	49.1%	22.4%	38.1%	50.0%	51.3%
Rain water	n	7	16	0	3	0	0	26
	%	9.7%	22.2%	0.0%	6.1%	0.0%	0.0%	6.8%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Likelihood Ratio	Value =118.568, df=10, p= .000							

Source: Questionnaire Survey, June-October, 2016

Therefore, in present study an attempt has been made to see whether the tube wells are arsenic free or not. It reveals that 27.27% of respondents village had known that the tube wells they are using is arsenic tested (table 9.25). Few of them had known that tube wells are not arsenic tested. On the other hand, more than half of the respondents in all six unions answered negative about arsenic test of tube wells. Significant difference exists among the unions regarding the consciousness about arsenic contamination on tube well water. Therefore, irrespective of village locations, tube wells need to be screened and more important to aware people about the danger of drinking water from arsenic contaminated tube wells.

Table 9.25: Distribution of Household by Perception about Arsenic Test of Tube Wells

Tube well Arsenic tasted		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Yes	n	1	2	11	9	21	0	44
	%	10.0%	20.0%	37.9%	25.7%	40.4%	0.0%	27.7%
No	n	9	8	18	26	31	23	115
	%	90.0%	80.0%	62.1%	74.3%	59.6%	100.0%	72.3%
Total	n	10	10	29	35	52	23	159
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Likelihood Ratio	Value =22.507, df=5, p= .000							

Source: Questionnaire Survey, June-October, 2016

[23] https://www.hrw.org/news/2016/04/06/bangladesh-20-million-drink-arsenic-laced-water (accessed 15 November 2016).

9.9 Household Health Security

Livelihood security evaluation includes some important measures of household health security in Bangladesh context. These comprise frequency of sickness among the members of a household, access to primary healthcare facilities, and incidence of diarrhoea disease. Sickness of family members significantly reduces the productivity of household, such as reduce level of income which affects food and nutritional security and other aspects of livelihood security. This indicator of health security includes child immunization, frequency of sickness episodes, type of sickness, working days missed due to sickness, and types of treatment enjoyed by each member. Access of primary health care includes level of access of household members to appropriate healthcare services offered by government, NGOs and private authorities. Likewise, incidence of diarrhea is considered as a proxy measure of the quality of health and sanitation condition of a household.

9.9.1 Immunization of Children

Children's immunization is a basic primary healthcare facility offered by government with free of charge. Therefore, it is expected that all children should be immunized in proper time. But proximity of administrative headquarters and better communication with respect to distant location it varies.

The present study finds that about 70% of the total respondents are under the support of immunization and different reasons behind the rest for non-immunization. Significant difference exists among the villages in terms of children's immunization (Chi-square Value=17.288, df =5, p=.004). Gabura, Lalua and Khurushkul unions are found more disadvantageous situation than Munshigonj, Nilgonj and Khurushkul. In Munshigonj, Nilgonj and Khurushkul union the portion of immunized children are 81.9%, 75.5%, and 76.2% respectively. Non immunized portion are higher in Gabura, Lalua and Bharuakhali as 44.4%, 33.3% and 41.3% respectively which shows weaker health security situation for future adversity.

The present study also finds that children's immunization is significantly related with education level of household head. All the literate household heads had provided basic immunization to their children, while significant portion of households from illiterate category had not given immunization to their children. Likewise, immunization is found closely associated with income level of household head. Non-immunization of children is significantly higher among lower and middle income group than higher income group. The present study also explores the causes of non-immunization of children. It reveals that the households (total 115 out of 380) who had not immunized children were not aware about immunization or did not have any idea about immunization. Some were ready to immunize but nobody informed them prior to the immunization program start therefore they missed and few respondents thought that immunization is not important for children.

Table 9.26: Distribution of Household based on Immunization of Children by Union

Immunization of All Children of The Household		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Yes	n	59	40	38	37	64	27	265
	%	81.9%	55.6%	66.7%	75.5%	76.2%	58.7%	69.7%
No	n	13	32	19	12	20	19	115
	%	18.1%	44.4%	33.3%	24.5%	23.8%	41.3%	30.3%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Chi-square	Value=17.288, df=5, p=.004							

Source: Questionnaire Survey, June-October, 2016

9.9.2 Deaths of Children During Childhood

Death of children during childhood is one of the important indicators which show the health security status of locality. The rate varies on different criteria. In the present study the general notion of measuring under five mortality is not used which consider child mortality per 1000 of birth per year. But the present study considers number of the deaths of children in a household in its entire periods. This may not give the precise measure of under-five child mortality rate but will provide the idea about child deaths and household's health status. It reveals that 85% of the total respondents answered that they did not have deaths of children during the childhood. It is clearly found that majority of the respondents did not have incident of child death. Significant difference exists among the villages in terms of child deaths (table 9.27). Gabura, Lalua and Bharuakhali unions shows relatively higher deaths as 11.1%, 21.1% and 30.4% of the respondents than Munshigonj, Nilgonj and Khurushkul union as 9.7%, 18.4% and 8.3% of the respondents respectively. Majority of the child deaths were occurred during birth and due to the illness after birth, which are most common cause of death across the unions.

Other causes of deaths were accident and malnutrition, and mostly noticed in Gabura and Lalua union. Therefore, these unions are relatively more vulnerable to child death as compared with Munshigonj, Nilgonj and Bharuakhali union. In addition, the present study also finds significant association of child death with education level of household head. However, this could be linked to increasing awareness with increasing level of education of household head. Similarly, higher number of deaths also found among illiterate households, and child death reduces according to the level of education. However, other socio-demographic factors such as gender, livelihood group and income level of households are not significantly associated with child death.

Table 9.27: Distribution of Households based on Child Death by Union

Death of Children During Birth		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Yes	N	7	8	12	9	7	14	57
	%	9.7%	11.1%	21.1%	18.4%	8.3%	30.4%	15.0%
No	N	65	64	45	40	77	32	323
	%	90.3%	88.9%	78.9%	81.6%	91.7%	69.6%	85.0%
Total	N	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Chi-square	Value=16.024, df=5, p=.007							

Source: Questionnaire Survey, June-October, 2016

9.9.3 Type of Medicare Facilities Enjoyed by Household by Union

The present study finds that almost every household had experienced some sort of healthcare services for the treatment purposes of household members. However, significant difference exists among the areas in terms of health care facilities (Likelihood ratio=90.428, df=15, p=0.000). Present study also explores in detail the sources of health care services in six study areas. Village doctors and medicine shops were the primary sources of health care services in all six unions. However, in most of the case such doctors do not have any formal medical education or training. Few households had also received medical services from Upazila Health Complex and district hospitals. Private medicine practitioners are also one of the main sources of health care service in rural areas of Bangladesh including the study villages. On the other hand, NGO clinic and community clinics are mostly concentrated in the urban areas. The present study finds that few households in Munshigonj, Nilgonj and Khurushkul (which close to upazila headquarter) had received healthcare services from NGO and community clinics. Such medical services are relatively absent in remote areas such as Gabura, Lalua and Bharuakhali union (table 9.28). It is found here that in case of any future climatic event the disadvantageous location related to health security will be more susceptible to disaster.

Table 9.28: Type of Medicare Facilities Enjoyed by Household by Union

Medicare Facilities		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Village doctor	n	45	44	32	15	17	1	154
	%	62.5%	61.1%	56.1%	30.6%	20.2%	2.2%	40.5%
Homeopathic Doctor	n	9	6	11	12	21	24	83
	%	12.5%	8.3%	19.3%	24.5%	25.0%	52.2%	21.8%
Medicine Shop	n	9	14	9	13	29	13	87
	%	12.5%	19.4%	15.8%	26.5%	34.5%	28.3%	22.9%
Thana Health Complex	n	9	8	5	9	17	8	56
	%	12.5%	11.1%	8.8%	18.4%	20.2%	17.4%	14.7%
Total	% of Total	18.9%	18.9%	15.0%	12.9%	22.1%	12.1%	100.0%
Likelihood Ratio	Value=90.428, df= 15, p=.000							

Source: Questionnaire Survey, June-October, 2016

9.10 Household Educational Security

Education is the most required indicator that is essential to make livelihood secured. Basic education develops human skills. It is required to take part in knowledge-intensive income earning activities to ensure livelihood security and sustainable use of environmental resources for poverty alleviation.

Educated people are capable of diversifying economic activities through focusing on various non-farm activities at the time of extreme risk to secure livelihoods.[24] Considering the advantage of education, it is very important to assess educational status of household from livelihood security point of view. To assess the educational security, the present study employed several variables including level of education of household head, overall educational level of household members, gender differences in access to education and adult literacy rate of 7 years and above population. Overall educational level of household members includes the number of household members completed primary, secondary, college and higher education. Higher educational attainment of household members reflects relatively better access of household to educational facilities. Similarly, literacy rate of 7 year and above population revels overall literacy status of household.

[24] Mary Khakoni Walingo, "The Role of Education in Agricultural Projects for Food Security and Poverty Reduction in Kenya," *International Review of Education* 52, no. 3-4 (2006): 288.

The present study finds that majority of the household head in all six unions are illiterate (42.4% of total respondents). Number of illiterate household head is significantly higher in Gabura, Lalua and Bharuakhali union as 48.6%, 63.2% and 60.9% respectively. Similarly, household head having some kind of knowledge about reading and can write at least own name are considered for read and write category. It reveals that the portion is higher in Munshigonj and Khurushkul union as 47.2% and 51.2% respectively. Likewise, household head completed secondary school and above level education is significantly higher in Munshigonj, Nilgonj and Khurushkul as 12.5%, 8.2%, and 9.6% respectively.

A statistically significant difference was observed among the villages regarding education level of household head (table 9.29). Similarly, the present study finds significant relationship between education level of household head and various livelihoods groups. Number of illiterate household heads is relatively higher in fisher and wage labor livelihood groups than farmer. On the other hand, household heads having secondary school and above level education are significantly higher in farmer livelihood group.

Table 9.29: Education Status of Respondent

Education Status of Respondent		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Illiterate	n	21	35	36	15	26	28	161
	%	29.2%	48.6%	63.2%	30.6%	31.0%	60.9%	42.4%
Can read & write	n	34	31	15	21	43	11	155
	%	47.2%	43.1%	26.3%	42.9%	51.2%	23.9%	40.8%
Primary School	n	8	3	2	9	7	3	32
	%	11.1%	4.2%	3.5%	18.4%	8.3%	6.5%	8.4%
Secondary school/ College	n	9	3	4	4	9.6	4	32
	%	12.5%	4.2%	7.1%	8.2%	9.6%	8.6%	8.4%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Likelihood Ratio	Value =58.520, df=20, p= .000							

Source: Questionnaire Survey, June-October, 2016

9.11 Livelihood Security Exploration Due to Potential Impact of Sea Level Rise in Coastal Region

This study finds that more than 19.3% of households in Lalua Union of study area are 'absolutely' food insecure based on a daily per capita calorie intake of less than 2122 Kcal. Significant difference exists among the Unions in terms of caloric availability, where Munshigonj, Nilgonj and Khurushkul are found relatively more food secured.

Similarly, wage laborer livelihood group are found more food insecure in terms of per capita calorie intake than farmer and fisher. Based on the regression models, this study finds that indicators of maternal characteristics, household demographic and socio-economic characteristics, livelihood capitals are significant factors influencing food security. However, such influencing factors significantly vary across the areas based on available resources, demographic and socio-economic conditions. This helps to identify specific location those are vulnerable and need to strengthen the indicators that reduce intensity of future impact of SLR.

Like food security, other aspects of livelihood security such as nutritional status, income level, health-sanitation and drinking water facility, health care facilities and educational status of household members significantly vary across the areas and livelihood groups. Gabura, Lalua, Bharuakhali union significantly lacking behind in all aspects of livelihood security measures. Farmer livelihood group shows relatively better situation than fisher and wage laborer. In few cases such as educational security, fisher livelihood group reveals backward in all aspects. From nutritional security point of view, number of reproductive women having underweight, wasting and underweight of children is highly prevalent in Gabura, Lalua and Bharuakhali, while Munshigonj, Nilgonj and Khurushkul union reveal relatively better picture.

On the other hand, wasting is a severe problem in all six locations which is higher than national average. Likewise, majority of the coastal population are economically insecure and large number of households having an annual income of less than 70000 BDT, while average savings is significantly lower.

Most cases savings for lower income households are the security deposits to the NGOs, which are inaccessible during needs. About more than 50% of total household expenditure is for food consumption, and for poorer households such expenditure is more than 70%. Household borrow money from multiple sources. While they borrow money from one source to repay others thus creates dependency. Respondents of Gabura, Nilgonj and Bharuakhali union and wage laborer livelihood group reveal economically insecure in all aspects of economic security indicators. So, the future impact of climate change induced sea level rise will be comparatively higher on this region and livelihood group.

Housing of fisher and wage laborer livelihood groups, and as a location Gabura, Lalua and Bharuakhali union reveal the worse condition. Other issues such as sanitation and drinking water facility reveal significantly better in Munshigonj and Khurushkul union. Sanitation is relatively better in these unions because of NGO activities, while Gabura. Lalua and Bharuakhali union reveal poor sanitation situation which needs to be taken into account. Drinking water facility is homogenous across the villages and livelihood groups; though poorer households spend more time to collect water because of not having tube well is their dwelling units. So, resiliency for any future event of climatic disaster for the people of Gabura, Lalua and Bharuakhali union is fragile in terms housing and sanitation facilities.

Child immunization and deaths of children are great concern in Gabura, Lalua and Bharuakhali. However, incidences of diseases are mostly similar across the unions, though healthcare facility and affordability to pay for health care varies significantly across the villages. Gabura, Lalua and Bharuakhali reveal disadvantageous position than Munshigonj, Nilgonj and Khurushkul union. Similarly, educational attainment of household heads and household members reveals backwardness of Gabura, Lalua and Bharuakhali union than Inland and Munshigonj, Nilgonj and Khurushkul union. However, such differential pictures of various livelihood security indicators reveal relatively livelihood insecurity in Gabura, Lalua and Bharuakhali union, while Munshigonj, Nilgonj and Khurushkul union reveal relatively better of position. Among the livelihood groups farmer are relatively more secure than wage laborer and fisher. So, it can be concluded that potential impact of sea level rise will affect the livelihood security of Gabura, Lalua and Bharuakhali union considering the different indicators negatively than the three other unions of better position.

9.12 Chapter Summary

In the present chapter many indicators have been used to summarize the factors related to livelihood outcomes. Simultaneously, the direct measures of livelihood security a number of alternative indicators are also used. All can help in identifying vulnerable places and livelihood groups as well. Basically, livelihood security is measured based on several general categories such as food security, nutritional security, income security, shelter-water and sanitation security, health security and education security. The present study finds that the climate change related disaster like sea level rise would have devastating impacts on environmental, socio-economic conditions and livelihoods of people that results in the future disaster livelihood insecurity. Considering the food security in general majority of people had experienced availability of food for 7-9 months in a year. The situation would worsen the future period considering climatic event like SLR based on locational exposure, gender, income and occupation of households.

In coastal Bangladesh household food intake is highly centered on rice consumption and such rice consumption will decline based on decreasing the production. The present study finds that it is directly linked with locational exposure, gender, income and occupation of households. One quarter of respondents found that the amount of food usually consume was adequate, while only 23 % found quality of such food was adequate. Similarly, more than 80 percent of respondents were worried with high level of anxiety (in five point Likert scale) for future food consumption in future adverse situation which is linked with location, gender, income, education and occupation as well. Hence, such findings confirms that female headed households, lower income groups, illiterates and not fixed occupational groups such as day laborers and maid servants, and households in most exposed remote coastal locations are the most vulnerable to future climate change induced sea level rise disaster related food insecurity. A comparative aspects of livelihood security indicators in six unions have been given below (table 9.30).

Table 9.30: Comparative Aspects of Livelihood Security Indicators in Six Unions

Indicators	Study Unions						
	Munshigonj	Gabura	Lalua	Nilgonj	Khurushkul	Bharuakhali	Remark
Food Security							
Food Security (Food Secure Households in terms of >2122Kcal/day/person)	58.3%	38.9%	19.3%	69.4%	73.8%	41.3%	National Average 40%.[25]
Nutritional Security							
- Underweight Reproductive Women (BMI>18.5)	9.7%	19.4%	19.3%	8.2%	4.8%	26.1%	National Average 24.1%.[26]
- Wasted Children (below 5 years)	7.7%	12.5%	55.6%	57.1%	27.8%	37.5%	National Average 17.4%.[27]
- Underweight Children (below 5 years: weight-for-age)	38.5%	75.0%	77.8%	13.3%	22.2%	62.5%	National Average 41%
- Stunted Children (below 5 years)	30.8%	37.5%	22.2%	28.6%	16.7%	12.5%	National Average 40%.[28]
Economic Security							
- Average Annual Income BDT	63013	58680	54421	59857	72011	43391	National Average BDT 1,15,576
- Average Annual Expenditure BDT	60854	58423	50414	58131	64226	48043	National Average BDT 1,15,344
- Average Annual Savings	1569	583	-	408	5654	391	Field Survey
Shelter, Water and Sanitation							
Roofing material of house	CI Sheet 71%	Straw and Polythene 52%	Straw and Polythene 53%	CI Sheet 62%	CI Sheet 73%	Straw and Polythene 59%	Field Survey
Average room/HH	1.67	1.1	1.2	1.72	1.93	1.0	Field Survey
Household having toilet facility	37.5%	19.4%	21.1%	63.3%	63.1%	52.2%	National Average 87.06%
Drinking water (tube well m)	220	249	220	160	150	210	Field Survey
Health Security							
Child Immunization	81.9%	55.6%	66.7%	75.5%	76.2%	58.7%	National Average 89.366%
Child deaths during childhood	9.7%	11.1%	21.1%	18.4%	8.3%	30.4%	Field Survey
Annual average healthcare expenditure	3270	2875	1935	1995	2566	1991	National Average BDT 12600
Educational Security							
Illiteracy of Household Head	29.2%	48.6%	63.2%	30.6%	31.0%	60.9%	National Average 43.05%
Illiteracy of Household Members	31.08%	71.25%	77.25%	30.08%	25.08%	39.07%	National Average 39.07%
7 Years and above literacy	60.03%	26.12%	22.75%	59.32%	68.32%	25.10%	National Average 78.487%[29]

Source: Questionnaire Survey, June-October, 2016

[25] FAO, Special Report FAO/WFP Crop and Food Supply Assessment Mission to Bangladesh, (2008) available at http://www.fao.org/docrep/011/ai472e/ai472e00.htm (accessed 10 November 2016)

[26] UNICEF. Child and Maternal Nutrition in Bangladesh, available at http:// www.unicef.org/bangladesh/ Child_and_Maternal_Nutrition.pdf, accessed on November 13, 2016

[27] National Institute Of Population Research and Training. *Bangladesh Demographic and Health Survey 2011*. Mitra and Associates Dhaka, Bangladesh (Dhaka: April 2012), 169.

[28] Ibid., 170.

[29] Bangladesh Bureau of Statistics, *Report of the Household Income and Expenditure Survey 2011*. 31st ed. Bangladesh Bureau of Statistics, Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh (Dhaka: September 2012).

Chapter Ten
Summary and Conclusion

Climate change induced sea level rise is identified as major perturbating hazard that households in coastal Bangladesh are worried to face. Relevant literatures have also identified that such disaster with associated events are the main impediments for the sustainable development of Bangladesh, and main cause of household's socio-economic underdevelopment and livelihood insecurity particularly in coastal areas.[1] As per the hypothesis proposed by Chambers and Conway (1992) that livelihood is sustainable or secure if it can cope and recover from shocks through its capabilities and assets.[2] In view of this core concept of livelihood security the present study considers livelihood security as the outcome of livelihood strategies that include various coping measures to combat the adversity posed by sea level rise. Such livelihood outcomes could be maintaining or improving household income level, livelihood assets, and physical and social well-beings. In all the study areas, people recurrently battle against different hazards, and use ranges of indigenous coping strategies to maintain the equilibrium. However, such equilibrium takes place if household expenses are roughly equal to its income and are capable to manage from its own source by employing various coping measures. However, if such disasters force household to combat the crisis through spending more than its income, and force to adopt various passive coping measures such as reduction of its assets (selling of cattle or land) become increasingly vulnerable to impending disaster and unlikely to achieve livelihood security.[3]

It is found in all the study areas that external assistance from different organizations plays a vital role to prevent households to adopt passive coping measure to achieve desired goal of livelihood security. However, this study revolves around the questions what makes livelihood of coastal communities vulnerable, and what underlying coping measures

---

[1] M. Shah Alam Khan, "Disaster Preparedness for Sustainable Development in Bangladesh," *Disaster Prevention* and *Management: An International Journal* 17, no. 5 (2008): 665

[2] R. Chambers and R. Conway, Sustainable Rural Livelihood: Practical Concepts for 21th Century, Institute of Development Studies and Poverty Research Unit, University of Sussex, *IDS Discussion Paper* 296(1992). Available at *https://www.staff.ncl.ac.uk/david.harvey/AEF806/Sconnes1998.pdf* (accessed on 15 March 2016).

[3] T. Frankenberger, *Measuring Household Livelihood Security: An Approach for Reducing Absolute Poverty*. Paper prepared for the Applied Anthropology Meetings, Baltimore, March (1996) available at *http://www.fao.org/3/a-x0051t/X0051t05.htm* (accessed on 18 June 2016).

household usually adopts to secure livelihoods, and what factors determine variation in adoption of coping measures, and achieving differential livelihood security outcomes.

10.1 Summary of Findings

The main findings of the present study are summarized below.

10.1.1 Potential Impacts of Climate Change Induced Sea Level Rise

Impact of SLR on livelihood security depends on time period according to the physiographic, demographic, socio-economic and cultural factors. Chapter 5 of the present study examined the geophysical conditions and impacts of SLR in the study areas. Review of existing literature finds that study areas are historically vulnerable to various climatic events.

The present study finds that among the six study locations Gabura, Lalua and Bharuakhali unions experienced significantly higher level of vulnerable position whereas better position remains in other three unions as Munshigonj, Nilgonj and Khurushkul in terms of different impact of sea level rise. The perceptions of the respondents of the study area also support the situation which is consistent with some earlier studies.[4] Such findings reveal potential vulnerability is higher in Gabura, Lalua and Bharuakhali than that of other three unions as Munshigonj, Nilgonj and Khurushkul.

This section compiles the findings of impact of SLR in accordance with the study objectives that were analyzed on the purpose of the study. The findings of the impacts are:

Salinity level increase: The study reveals that the level of salinity of the study area is increasing rapidly. Continuous tidal inundation and saline water logging due to SLR is highly responsible for increasing the level of salinity. Due to the increase of salinity level, the potentiality of land to cultivate crops also decrease.

Increasing food insecurity: The loss of agricultural production due to salinity will create severe food insecurity. The maximum people of the study areas have been living under the poverty line. The increasing insecurity of food has negative impact on the health and nutrition of the study areas.

[4] M. Shah Alam Khan, "Disaster Preparedness for Sustainable Development in Bangladesh," *Disaster Prevention and Management: An International Journal* 17, no. 5 (2008): 667.

Unemployment problem: It is found in the study that disruption of production will decrease the employment opportunity. The unemployed inhabitants of the study areas will migrate to other places for work. Problems of unemployment will result in different socio-economic imbalances.

Changing pattern of economic activities: The primary economic activities are highly vulnerable to CC-SLR of the study areas. This changing pattern will push them to non-agricultural activities.

Impact of land use pattern: The suitability of land will become hampered because of salinity of soil. As a result, once fertile cropland will be converted to shrimp farms. It will create another adverse impact on agriculture based economy of Bangladesh.

Loss of homestead: Due to the rise of water level and intrusion of salinity, a significant number of people will lose their homesteads and will become climate refugees. The maximum people who lose their homesteads migrate to other places and some of them will raise their foundation of homestead land to survive.

Impact on health: The losses of agricultural production would have negative impact on the food security and nutrition level of the people of the study areas. The majority of the population will suffer from malnutrition which has serious health impact. Moreover, high level of salinity in water creates skin and water borne diseases.

Impact on fisheries sectors: The fresh water fisheries sectors are now in danger due to high saline water intrusion in fisheries dependent coastal livelihood. The sudden increase of soil and water salinity have upset natural equilibrium of the delicate ecological balance of the fresh water fisheries of the study area.

Increasing migration and climate change refugee: Due to loss of dwelling and agricultural land the production will be severely affected. As a result people are forced to migrate other places for livelihood security.

The population of coastal Bangladesh will have to face a number of adverse impacts regarding livelihood security. So, they have to find indigenous coping strategies which will significantly help to lessen the intensity of impact of SLR and save lives. It is found that future impact will be varied in terms of gender, socio-economic, demographic and cultural factors which all will differentiate the impacts of hazards. It is evident from the findings of the study that the future severity of SLR impact with associated impact will immensely disrupt the livelihood security of coastal people.

10.1.2 Assets Portfolio and Livelihood Strategies

Livelihood assets of coastal households vary from one place to another depending on physical location, geo-physical condition, institutional environment and social classes. A household usually makes strategic choices to use livelihood assets for income generation and facing the vulnerabilities from multiple stressors, and adopt variety of strategies to secure livelihoods. In order to understand and make comparison among study areas and livelihood groups, quantification of livelihood asset has been done.

The findings of this study reveal that human capital index value is relatively higher for Munshigonj and Nilgonj union than that of Lalua and Gabura Union. Major implications of such finding are Munshigonj, Nilgonj have better accomplishment to work in adverse conditions, having knowledge and training about income earning and disaster risk reduction, higher ability to solve problems and facilitating community activities. On the other hand, lower human capital index value of Gabura, Lalua union need special attention to improve human capital for enhancing income earning capacity and combating disasters in view of achieving livelihood security.

The study finds higher natural capital index value for Gabura, Lalua and Bharuakhali than Munshigonj, Nilgonj and Khurushkul union. Open access common source resources such as sea, river, grazing lands, khas lands and coastal forests are major causes of higher natural capital index value of Gabura, Lalua and Bharuakhali union. While other three unions are agro-based and limited common source resources are available and consequently natural capital revel lower value.

Similarly, physical capital index value is higher for Munshigonj, Khurushkul union followed by Gabura, Lalua and Bharuakhali unions. Such findings reveal higher access and ownership of physical assets such as fishing and agricultural accessories by Munshigonj, Khurushkul union. While Gabura, Lalua and Bharuakhali unions do not require much investment for agricultural accessories, and settlers from outside who mostly engaged in subsistence fishing. Therefore, physical capital of Gabura, Lalua and Bharuakhali unions reveal relatively lower value than that of Munshigonj, Nilgonj and Khurushkul unions.

Likewise, financial capital index value is comparatively higher in Munshigonj, Nilgonj and Khurushkul unions than Gabura, Lalua and Bharuakhali unions. This finding confirms the relatively poorer economic conditions of Gabura, Lalua and Bharuakhali unions than Munshigonj, Nilgonj and Khurushkul unions.

Similarly, social capital reveals similar trends of higher index value for Munshigonj and Nilgonj unions. Lower social capital index value for Gabura and Bharuakhali unions unveil relatively lesser social network and coherence of inhabitants which is most important to survive in disaster situation.

The present study also identified major livelihood groups in study villages such as famer, fisher and wage laborer. Among the livelihood groups, wage laborers having less livelihood capitals than farmer and fishermen. Such findings unveils relatively weaker asset portfolio of wage laborer than farmer and fisher. Between farmer and fisher human and social capital index value is higher for farmer group, while natural, financial and physical capital index value is higher for fishermen.

Higher human capital unveils better physical ability, skill and knowledge, and higher financial capital reveals higher ability of converting liquid assets and savings to gain other capitals, while higher social capital reveals relatively better participation and connection with various community groups and activities of farmer groups. On the other hand, higher natural capital index value of fisher group reveals relatively higher access to common source resources such as sea and river for fishing, which requires relatively higher investment for boats, nets and other fishing accessories. Therefore, physical capital reveals higher index value for the fishers than the farmers.

The findings confirm that Gabura, Lalua, Bharuakhali and wage laborer livelihood group is relatively resource poor. Consequently, it can be argued in this study that due to the lack of livelihood capitals Island village as a location and wage laborer as a livelihood group remain more vulnerable to future impact of sea level rise or other natural hazards. In addition to identifying the livelihood asset portfolio of six sampled unions and major livelihood groups, major adversities and crisis for different livelihood groups and sub-groups, their activity time and lean periods, major risks and uncertainties are also identified.

Salinity intrusion, cyclones and storm surges are identified as main natural calamities faced by most of the surveyed households which significantly destroys their livelihoods irrespective of their village locations. Similarly, the study also finds that most of the coastal households do not dependent on single income earning activities. Households in all the study unions diversify income sources wherever possible and most importantly while face the crisis. Such diversification of income earning activities confirms the transformation process of traditional typical coastal livelihoods.

10.1.3 Indigenous Adaptation Strategies for the Impact of Sea Level Rise on Livelihood Security

Following the objective of identifying coastal community's indigenous coping response to sea level rise, and underlying contributing factors for variation in adoption of such coping strategies, the study firstly identifies the household coping strategies to mitigate the impact of sea level rise and secondly identifies their options by using multiple response analysis. The study finds that in response to potential impact of sea level rise people of the study area habitually come up with various indigenous coping strategies following the sequences of different stages of sea level rise.

The findings of the present study reveal that coping strategies in advance of future sea level rise event comprises preparedness measures including response to early knowledge and information of such natural hazards. Radio and television is identified as important media for sea level rise information. However, people cannot take full advantage of SLR information due to the lack of access to radio and television.

Among the six unions less than one-fifth of the respondents have own radio or television, and in the case of Gabura, Lalua and Bharuakhali unions percentage is significantly lower, and very few respondents have regular habit of listening to weather forecasting. Similarly, two-thirds of respondents do not follow SLR information because of family needs extra earning to meet basic requirements and not having radio or television.

This finding of the study confirms the results of a number of earlier studies.[5] Therefore, this study confirms the reliability and proper information of SLR event is prerequisite for proactive coping response of different future stages of impacts.

It is found that the coastal people have been trying to cope and adapt against series of disastrous events time and again. They have developed various sets of coping and

[5] C. Emdad Haque and Muhammad Qasim Zaman, "Human responses to riverine hazards in Bangladesh: a proposal for sustainable floodplain development," *World Development* 21, no. 1 (1993): 95.

adaptive measure to secure their lives and livelihood. Some coping and adaptive measures are very common, i.e. used for multiple situations; some are used by them in specific conditions. Though SLR is new idea of threat for the coastal region of Bangladesh, the respondents were given the different stages of SLR scenarios and were asked to share their idea about coping and adaptation strategies.

The potential scenarios of SLR were explained in brief before taking interview of the respondents. Respondents were asked to narrate the ways of adaptation. They were further interviewed, what they or their future generation would probably do if their livelihood becomes insecure due to the impacts of future SLR and its associated events. From numerous responses, ultimately the likely occurrence of forced migration from the coastal tract was counted.

Adaptation Measures of Salinity Intrusion for Agriculture

The outcome of FGD shows that the whole study area is more or less affected by salinity. Fertility of land has been decreasing rapidly and sea level rise will trigger up the situation of increasing salinity. As a result agricultural sector is seriously threatened.

To address the situation in 2030 the study finds that flood and salinity tolerant crops are the best responses for adaptation regarding salinity followed by time of cultivation change and changes in cropping pattern was the comparatively best responses. It reveals that for the situation 2050 the highest response was for high yield crop verities as followed by Salinity tolerant crops. Salinity management for 2100 situation regarding sea level rise most of the respondents answered with uncertainty about management.

Adaptation Strategies for Crops Management

To reduce the intensity of impact on crops the respondents were asked to find the possible measures of the study area. During evaluation of crop losses, major SLR induced risk factors were also identified. Agriculture of the study area is dominated by rice production. For present time the responses for Local paddy verities (BR 10, 11, 23, BRRI 28, 30) is highest followed by Purbashi, Jamai Babu. For situation 2030 BRRI 41, 49 hold highest response followed by Lal Teer, Khaja lota, Chaina. Crops adaptation for 2050 they responded for BRRI 40, 47 followed by Heera, Shahab Kachi, Mala gati, Sada Gutal, Bina and Bina 7,8,9. For 2100 situation they responded Kajol shail, Hummi, Nonakochi which are highly salinity tolerant crops and major responses were in uncertainty.

Adaptation Measures for Fisheries

The respondents narrated various measures of fisheries in terms of different scenarios of SLR. For the present management, they answered about fish cultivation in internal pond, local fish, cultivation in normal time. For 2030, strategies are cultivation in internal and open pond, local tolerant fish and change in management. For 2050, the responses of strategies are risk free shallow water cultivation, saline tolerant fish, cultivation in changing time. For 2100, the responses of the strategy is highly saline tolerant fish and they mentioned uncertainty for the period.

Adaptation Measures for Settlement in Different Stages of SLR

Presently their management responses for settlement are normal area, normal foundation, and forestry around the shelter. In present situation they are not anxious about settlement. For 2030, the strategies are change in base foundation, safe area, modification in construction material. For the management of 2050, responses are raising plinth of houses, selection of safe area, change in structure, forestry around the shelter. Sea level rise scenario for 2100 the responses are extra raise base foundation and a significant portion was as unknown category of adaptation.

Adaptation Measures for Land use in Different Stages of SLR

Due to salinity adversity of SLR impact, the respondents think about land use pattern adaptation. The response of land use for present situation the responses are crops, shrimp, fruits and vegetables, fresh water fishing. In 2030, for reducing the impact of SLR, the responses regarding land management are soil tolerant crops, shrimp in fresh water. For the land use management of 2050, the responses are highly saline tolerant crops, dam agriculture, extensive shrimp culture. The respondents think that 2100 for sea level rise would have huge uncertainty for land use management. The responses were extensive shrimp culture, floating dhap, use of fallow land.

Nonagricultural Activities Adaptation

It is revealed in the study that the responses of present practices are as regular production, usual storage. In present position it is found less anxiety and normal activities was given preference. For 2030 situation management, the responses were normal production and safe storage. In situation 2050, the preferred answers of the respondents were new production system and new storage strategy. In this situation their answers hold anxiety for future incidence of sea level rise. The respondents are very anxious about the situation of 2100, regarding sea level rise scenarios. A significant number respondents expressed their unbound uncertainty. For the management of the situation their preferred answers were as change in raw material, safe storage and unknown category of responses.

Occupational Adaptation Activities

It was revealed that the respondents were concerned about their in general occupational adaptation strategies. For present time occupational activities their responses were as agricultural activities, and aquaculture, shrimp cultivation, NGO related job. For the situation 2030 their responses were as animal husbandry, poultry, fishery, shrimp, fishery/shrimp, and transportation. For 2050 situation of sea level rise, their responses were as combined agriculture, local and sea fish, day labor. For 2100 situation, they responded as homestead gardening, labor and option for migration. It was found that the main strategies available to poor people with no access to resources are migration. It is also found in the study that sea level rise problem will extend the lean period so that more and more people are forced to migrate. Most of the migrants migrate in the nearby divisional or district towns. Livelihood failure and destruction of income sources are the main causes of migration which are revealed in this study.

These strategies for adaptive management to prepare for the impacts of sea level rise in order to enhance safeguard of community, environment and economy from likely risks. Therefore, finally it is found in the study that for different scenarios of sea level rise, the inhabitants of coastal area plan to take various options for livelihood security and to increase the resilience against the impact of sea level rise. It is also found for 1 m sea level rise by 2100, there is uncertainty among the inhabitants regarding adaptive strategies.

10.1.4 Institutional Support Mechanism for SLR Induced Disaster Mitigation and Livelihood Security

In line with the objective of 'exploring institutional support mechanisms and services available for SLR induced disaster risk reduction that influence livelihood and adaptation strategies' are identified in the chapter 8 of this study. Based on this objective, review of existing literature finds that Bangladesh government has made significant progress in disaster management in recent years due to its well established set-up of disaster management institutions in all departments and administrative tiers. Comprehensive disaster management plan, standing orders on disaster, and disaster preparedness program are successful initiatives for disaster management at policy level. Community risk assessment and participatory risk reduction action plans are some of the successful initiatives to involve community in disaster risk reduction process. Similarly, reducing risk factors, introducing saline and drought tolerant crop verities, coastal aforestration, and introducing disaster management issues in education system have proven fruitful in recent years. Likewise, food for work is the most effective program to ensure food security to women vulnerable to various disastrous events.

Despite having huge success in disaster management, few limitations are identified in the present study, such as uncertainty in SLR information, and proper and timely broadcasting of climatic event message. Remote Islands (Gabura, Lalua and Bharuakhali) and char lands are to be given special priority for preparedness, evacuation, relief, rehabilitation and rebuilding livelihoods.

However, the present study finds that inhabitants of Gabura, Lalua and Bharuakhali had received relatively lesser support of information, other assistances, and assistances for livelihood rebuilding. Similarly, respondent's gender, education, occupation plays crucial role in receiving of support and rehabilitation assistances. Households having good socio-economic status are more likely to receive better organizational assistances for disaster risk reduction. Such finding is consistent with previous studies that socio-economic status of households are positively related with the receiving of climatic warning.[6] Therefore, findings of this study advocate that most disadvantaged places and groups need to be given special priority for preparedness, evacuation, relief and assistances for restoring livelihoods.

Similarly, different disaster assistance activities of different government and non-government organizations were found concentrated on the areas located close to the thana headquarters or having good communication networks, and NGOs focused mostly their members for relief and rehabilitations. The present study reveals that Munshigonj, Nilgonj and Bharuakhali which are nearer to administrative headquarter get higher disastrous assistance. Such finding confirms that NGOs activities are limited to the places

[6] John H. Sorensen, "Hazard Warning Systems: Review of 20 Years Of Progress," *Natural Hazards Review* 1, no. 2 (2000): 121.

where their projects are in effect and not likely to work in most exposed coastal zones such as Gabura, Lalua and Bharuakhali.[7] Little or non-existence of the activities or inaction of volunteers, local government organizations and NGOs in remote locations urge special attention for better preventive measures in future events of SLR for livelihood security.

Rehabilitation activities should acknowledge the real needs of SLR victims such as rebuilding of livelihoods, income generating activities etc. However, present study finds that few of the organizations had provided such assistance considering the real needs of SLR impact for rebuilding livelihoods to enhance resilience. Such finding reveals that assistance is still crisis oriented and immediate, and not usually proactive to assist for future impact of SLR in the coastal region of Bangladesh. Therefore, future income generating activities need to be prioritized as the present study identified to save SLR victims from disaster and make their livelihood option more secured. Simultaneously, the present study finding suggests that coordination among different NGOs and local government organizations is a pre-requisite for ensuring the successful implementation of any rehabilitation program for SLR induced disaster.

10.1.5 Livelihood Security of Coastal People Against SLR

Considering the objective of 'assessing livelihood security of coastal communities and identifying the underlying factors that influence livelihood security', chapter 9 of this study used several categories of indicators and summarizes a variety of factors related to livelihood security outcomes. Broadly livelihood security outcomes fall in several general categories such as food security, nutritional security, income security, shelter-water and sanitation security, health security and education security. The present study finds that sea level rise has devastating impacts on environmental, socio-economic conditions and livelihoods of people that results in the future livelihood insecurity in different phases of sea level rise.

Findings of this study reveal that majority of the households experienced availability of food for 6-9 months in a year. The situation will worsen the position during the period of future impact of SLR. Household food intake is highly centered on rice consumption that reveals less dietary diversity and lacking of other types of nutrients. One quarter of

[7] D. Mustafa, "Reinforcing Vulnerability?" Disaster Relief, Recovery, and Response to the 2001 Flood in Rawalpindi, Pakistan. *Environmental Hazards* 5, (2003):74.

respondents found that the amount of food usually consume was adequate, while less than one-quarter found quality of such food was adequate. Though majority of the respondents were lacking of food in terms of both quantity and quality but in general they were satisfied on quantity of food and moderately satisfied on quality of food usually based on five point Likert scale. Hence, it can be expected that future impact of SLR will further affect the food security of the coastal zone.

Focus group discussion and key informants' interviews find that such satisfaction behavior of coastal people is linked with fatalism. Moreover, such finding unveils fatalism also leads to more psychological strength to the victims to battle against future SLR impact. Similarly, more than 80 percent of respondents were worried with high level of anxiety (in five point Likert scale) for future food consumption during future impact of SLR which is linked with location, gender, income, education and occupation as well. Hence, such findings reaffirms that female headed households, lower income groups, illiterates and unstable occupational groups such as day laborers and maidservants, and households in most exposed remote locations are the most vulnerable to future event of SLR in terms of food insecurity.

This study also finds that more than 22% of households are 'absolutely' food insecure based on a daily per capita calorie intake of less than 2122 Kcal, and 25 percent are hard-core food insecure with caloric intake of 1805 Kcal.

Among the unions, Gabura, Lalua and Nilgonj union, and among the livelihood groups wage laborer appear as relatively food insecure in terms of per day per capita calorie availability. A majority of the food insecure population were in the low income category which was attributed to a number of demographic, socio-economic and physical environmental factors. Based on the regression model, this study finds that amount of land, human capital, total number of dependent family member, gender of household head, annual household expenditure on food, and house wife's year of schooling are the significant predictors of calorie intake which will be affected by future events of sea level rise. Such finding helps identify both types of indicators those enhance and reduce SLR impact of food security in a specific location. Therefore, identification of such indicators in a specific geographic location might help for further interventions to improve household food security situation after the onset of disaster.

Finding of this study reveals that relatively more number of women fall in the underweight category in Gabura, Lalua and Nilgonj union from nutritional security point of view. This represents women's malnutrition and results in the great risk of offspring's mortality. Similarly, prevalence of wasting among under five year of children is higher than the national average (17%) and more number of wasted children is found in Gabura, Lalua and Bharuakhali union. Likewise, percentage of underweight (weight for age) children are relatively higher in Gabura, Lalua and Bharuakhali while Munshigonj, Nilgonj and Khurushkul union are relatively better off nutritional situation, which is less than national average (48%). Though significant variation does not exist among the villages but still stunting appears as a severe problem in all six unions as it is more than the national average (40%). However, in different phases of sea level rise nutritional scenario would worse in Gabura, Lalua and Bharuakhali union which need to be taken in to account.

Findings of the study reveal that majority of the surveyed households are economically insecured and income distribution is highly skewed. A large number of households have an annual income of less than 45000 BDT (below national average of 1150$ per year), while average savings is 23393 BDT (less than 400$). Most cases savings for lower income households are the security deposits to the NGOs, which are inaccessible during needs. Similarly household expenditure pattern is also highly skewed. About 50% of total household expenditure is for food consumption, while poorer households spend more than 60%. Household borrow money from multiple sources. While they borrow money from one source to repay others thus creates dependency on borrowing. Similarly, all household economic security indicators are associated with village location, gender, and education and livelihood groups. Hence, weaker economic based group and location are highly vulnerable to future impact of sea level rise.

Housing in Gabura, Lalua and Bharuakhali unions reveal decaying condition due to the poor economic conditions of households. Other issues such as sanitation and drinking water facility also reveal same situation. Sanitation is relatively better in Munshigonj, Nilgonj and Khurushkul unions because of NGO activities, while Gabura, Lalua and Bharuakhali union reveals poor sanitation situation which needs to be taken into account. However, in general access to sanitation in surveyed unions is lower than respective the Upazila and District average, and significantly associated with income and primary occupation of households. Drinking water facility is homogenous across the unions; though poorer households spend more time to collect water because of not having tube well in their dwelling units. Child immunization and deaths of children are great concern in Gabura, Lalua and Bharuakhali union; 30% of households have not immunized children and child death is also significantly higher. However, incidences of diseases are mostly similar across the unions, though healthcare facility and affordability to pay for health care varies significantly across the unions. In this regard, Gabura, Lalua and Bharuakhali union reveal disadvantageous position than Munshigonj, Nilgonj and Khurushkul in health security point of view. It reveals that insecure unions are highly vulnerable to potential impact of sea level rise.

Similarly, educational attainment of household heads and household members reveals that significant number of illiterate population are found in Gabura, Lalua and Bharuakhali unions than that of Munshigonj, Nilgonj and Khurushkul unions.

Findings also reveal that stipend and food for education are influencing factors for sending girls to attend the school, while child labor, early marriage and distance from the schools are few factors for early dropping out of girls from school. However, such differential pictures of various livelihood security indicators reveal relatively livelihood insecurity of Gabura, Lalua and Bharuakhali unions, while Munshigonj, Nilgonj and Khurushkul unions reveal relatively better off position. Among the livelihood groups wage laborer appear as the most disadvantageous group in most of the livelihood security indicators and vulnerable to SLR impact.

However, the present study finds that Impact of SLR on household livelihood security varies according to location and socio-economic factors (gender, income, education etc.). Thus, it is important to identify vulnerable locations and groups through scientific analysis of livelihood security indicators and indices. Improving socio-economic status of targeted groups is prerequisite to minimize future SLR livelihood insecurity. Thus emphasize need to be given on girls education, community based health and nutrition education and incorporation of disaster preparedness, calorie consumption and nutrition issues in the text books at school level in disaster prone areas. Likewise, intervention is needed for household asset buildings as all types of livelihood assets are significant predictors of livelihood security.

Inhabitant’s anxiety in terms of food accessibility has negative influence on future food security; thus priority for assistance and rehabilitation should be given to those groups who are at the bottom of such coping behavior. Future income diversification appears as a significant predictor. Hence, safety net programs need to be emphasized and continued with specifically targeting the absolute poor and hardcore poor and made more effective through proper monitoring. Moreover, emphasize should be given on re-building livelihood such as assistance for producing food rather than providing food. In other words supports should be expanded for income generating activities for the rural poor in disaster prone areas which could reduce the prevalence of future SLR disaster events on livelihood insecurity.

10.2 Conclusion

Livelihood security depends on various factors. Low income is a major concern of households of rural livelihood insecurity in coastal Bangladesh. It is a vital factor of households that leads to poverty. Therefore, reducing household’s vulnerability as well as poverty is prerequisite for achieving livelihood security. Vulnerability is a dynamic concept which is directly linked with ownership and controlling rights livelihood assets. Moreover, personal and covariant shocks, income variability, changes in macro-economic policy increase the physical and economic insecurity of households that ultimately impede the long term well-being or livelihood security of households. Potential impacts of sea level rise with associated events have overwhelming impacts on socio-economic conditions, infrastructure and environment which significantly hinders the livelihood security of coastal people. These impacts depend not only on the locational exposure and magnitude of disasters, but are also linked with several demographic, socio-economic, cultural and other exogenous variables. Nearer to coastline unions, remote char lands and wage laborer livelihood groups are the most vulnerable to sea level rise induced hazards.

In response to sea level rise impact, people habitually plan for various indigenous adaptation strategies following the sequences of different scenarios of sea level rise situation. Adoption of such strategies varies over perception of the people in line with various socio-economic and cultural factors such as income, education, livelihood group etc.

Female headed or less educated household heads have a lower ability to absorb shocks and mostly adopt passive coping measures, which increase their vulnerability to disaster. Similarly, landownership, income and occupational status have also significant influence on the adoption of adaptive measures. In this regard, respondents of well of position have a higher capacity to procure food and higher ability to capture forecast information for reducing disaster vulnerability. In addition to the socio-economic variables, locational factor, magnitude and intensity of the disaster, people's perception of forecasts, informal risk-sharing within the community and social protection measures play a vital role. Moreover, this study finds that the most exposed locations, such as Gabura, Lalua and Bharuakhali unions with high level impact of SLR, have negative influences on the inhabitants' coping ability.

People's perception about the quality and reliability of disaster forecasts also plays a pivotal role for future preparedness and adoption of coping measures. Appropriate distribution of assistance and undertaking rehabilitation activities in association with community support and response mechanisms can significantly contribute to ensure post disaster livelihood security.

The findings reveal that NGOs assistance are highly centered among the members, and mostly non-exposed locations. Improving the efficiency of both government and NGOs for disaster risk reduction with the main goal of ensuring livelihood security of disaster victims are highly imperative. Similarly the present study confirms the livelihood insecurity of Gabura, Lalua, Bharuakhali and remote char lands in terms of all the livelihood security indicators.

Therefore, careful monitoring and understanding of local adaptive behavior and identification of the rationale behind the adoption of such adaptation methods are to be considered. Assessment of livelihood security status and identifying insecure groups and places, and factors influence livelihood insecurity can substantially support those who are at risk of impending sea level rise hazards. It is extremely important to promote the integration of disaster management planning in long term development process with special focus on the poor as priority group and vulnerable zone as priority place for future SLR disaster management, rehabilitation and rebuilding livelihoods in coastal Bangladesh.

10.3 Policy Recommendations

Findings of the study unveil that the economic, humanitarian and livelihood security points of view, it is essential to take measures to minimize the intensity of future sea level rise impacts, build assets and secure future livelihoods of coastal communities irrespective of their dwelling locations. In order to do that the critical task of government and non-government organizations is to create an enabling environment for all six unions through which vulnerable coastal households (female headed, wage laborer, lower income, illiterate and absolutely landless) can increase their asset base. Specifically, Gabura, Lalua and Khurushkul reveal lower level of human capital index value. Therefore, skill enhancement training programs especially for subsistence fisher, small farmer, landless and female headed households in these unions could significantly help to build human capital to face the adversities induced by SLR. Natural capital index value is higher for these villagers, but due to the lower level of physical capital the opportunities of natural capital remain underutilized. Therefore, access to credit or direct assistance for building physical capital could be beneficial for above mentioned target groups of vulnerable locations that could help to secure future security of livelihoods.

Likewise, the present study findings reveal that indigenous coping strategies are effective until disaster cross the tolerable limit. Therefore, the present study advocates for promoting and upgrading current indigenous coping practices with additional inputs from government and non-government organizations in line with the community perception regarding critical or tolerable limits of such coping strategies for combating impending SLR events irrespective of locations.

Triangulation can be done with more in-depth longitudinal study mostly focusing the local peoples' adaptive thinking and by acknowledging community perception before undertaking any conclusive measures. Similarly, identification of variables that stand for adaptive strategy of individuals or groups might help lunching specific programs by targeting specific groups of people to reduce the vulnerability to specific disaster such as SLR with the broad goal of achieving future livelihood security. Emphasis should be given on improving the efficiency of the local level authorities who transmit this to community people for adoption of relatively better adaptive measures. Likewise, awareness enhancing program for SLR, dissemination of SLR information, agricultural assistance program, community awareness and preparedness program, building more safe shelters, coastal embankments and regular maintenance wherever necessary with coastal aforestation programs alongside the coastal embankments and other places considering community forestry concepts might create future livelihood avenues for disaster victims irrespective of village locations.

The present study finds the tremendous livelihood insecurity of Gabura, Lalua and Bharuakhali in terms of all livelihood security indicators. More specifically, food, housing, sanitation and education security of these unions urge special attention to combat against the impact of SLR. Other three unions have made more or less progress in access to sanitation and drinking water. However, there is still room for further improvement of all livelihood security indicators in all unions. Proper monitoring for programs, such as expansion of government's existing community food security programs, community insurance programs, rehabilitation considering future disaster livelihood rebuilding, informal education specially emphasizing vulnerable women, future employment generating programs considering vulnerable groups and places, introducing special social safety nets especially emphasizing coastal vulnerable places, emphasizing future rehabilitation considering natural resource based livelihoods activities might reduce the intensity of upcoming sea level rise induced impact and strengthen the livelihood security of coastal people of Bangladesh.

10.4 Future Direction of Research

While the study answers many research questions that are laid down in the introductory chapter, it does, however, leave some questions which signal future research directions. These are as follows.

- In-depth study on quantification of livelihood capitals and exact relation between them, and the specific role of each capital is important to identify option for better reduction of disaster risk to make the inhabitants more resilient and ensure long term livelihood security in terms of SLR.
- The future management of salt tolerant crops in coastal belt for agriculture which can strengthen food security as well as security for major livelihood option considering the reality of future SLR scenario.

However, this research could be a guideline for future researcher to achieve long-term livelihood security and sustainable development objectives.

Appendices

Appendix A Tables of Findings

Table 1: Primary Occupation of Household Head

Primary Occupation of Household Head	Study Unions						Total
	Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Agriculture	24	18	28	7	12	1	90
Share Cropper	2	0	0	0	0	0	2
Non-agri labor	2	3	6	9	10	1	31
Rickshaw / Van puller	0	0	0	5	0	0	5
Fishing	18	12	10	2	20	8	70
House helper / Maid	0	2	3	0	3	0	8
Petty business (<2000tk)	2	4	4	4	0	0	14
Business	5	10	1	15	20	6	57
Handicraft	0	0	0	0	1	6	7
NGO Worker	2	0	5	3	1	0	11
House wife	4	0	0	0	12	4	20
Dependent	0	3	0	0	0	0	3
Salt producer	2	0	0	0	5	18	25
Fish fry collector	8	11	0	0	0	2	21
Fish cultivator (pond / gher)	1	9	0	1	0	0	11
Driver(Mechanical)	2	0	0	1	0	0	3
Others	0	0	0	2	0	0	2
Total	**72**	**72**	**57**	**49**	**84**	**46**	**380**

Table 2: Type of Assistance Provided by The Different Organizations

Assistance		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Seed and Fertilizer	n	25	21	21	18	19	10	114
	%	73.5%	65.6%	77.8%	60.0%	79.2%	66.7%	70.4%
Goat	n	4	4	2	5	2	2	19
	%	11.8%	12.5%	7.4%	16.7%	8.3%	13.3%	11.7%
Boat and Net	n	3	6	2	4	2	2	19
	%	8.8%	18.8%	7.4%	13.3%	8.3%	13.3%	11.7%
Rickshaw/Van	n	0	0	0	1	0	0	1
	%	0.0%	0.0%	0.0%	3.3%	0.0%	0.0%	0.6%
Cow	n	2	1	2	2	1	1	9
	%	5.9%	3.1%	7.4%	6.7%	4.2%	6.7%	5.6%
Total	n	34	32	27	30	24	15	162
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Source: Questionnaire Survey, June-October, 2016

Table 3: Wall materials of House

Wall materials of House		Study Villages						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Pucca / Brick	n	5	3	0	0	0	0	8
	%	6.9%	4.2%	0.0%	0.0%	0.0%	0.0%	2.1%
Kutcha / dirt	n	6	28	10	0	0	0	44
	%	8.3%	38.9%	17.5%	0.0%	0.0%	0.0%	11.6%
Tin	n	44	23	29	39	53	23	211
	%	61.1%	31.9%	50.9%	79.6%	63.1%	50.0%	55.5%
Bamboo	n	16	15	14	10	31	23	109
	%	22.2%	20.8%	24.6%	20.4%	36.9%	50.0%	28.7%
Wood	n	0	0	4	0	0	0	4
	%	0.0%	0.0%	7.0%	0.0%	0.0%	0.0%	1.1%
Straw	n	1	3	0	0	0	0	4
	%	1.4%	4.2%	0.0%	0.0%	0.0%	0.0%	1.1%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 4: Roof materials of House

Roof materials of House		Study Villages						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Kutcha / dirt	n	0	3	0	1	0	0	4
	%	0.0%	4.2%	0.0%	2.0%	0.0%	0.0%	1.1%
Tin	n	56	45	32	45	61	24	263
	%	77.8%	62.5%	56.1%	91.8%	72.6%	52.2%	69.2%
Bamboo	n	4	8	0	0	13	16	41
	%	5.6%	11.1%	0.0%	0.0%	15.5%	34.8%	10.8%
Wood	n	1	2	15	0	0	0	18
	%	1.4%	2.8%	26.3%	0.0%	0.0%	0.0%	4.7%
Straw	n	11	14	10	3	10	6	54
	%	15.3%	19.4%	17.5%	6.1%	11.9%	13.0%	14.2%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 5: Floor Materials of House

Floor Materials of House		Study Villages						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Pucca / Brick	n	24	7	6	15	7	0	59
	%	33.3%	9.7%	10.5%	30.6%	8.3%	0.0%	15.5%
Kutcha / dirt	n	41	44	49	31	73	46	284
	%	56.9%	61.1%	86.0%	63.3%	86.9%	100.0%	74.7%
Tin	n	0	3	0	3	0	0	6
	%	0.0%	4.2%	0.0%	6.1%	0.0%	0.0%	1.6%
Bamboo	n	0	0	2	0	4	0	6
	%	0.0%	0.0%	3.5%	0.0%	4.8%	0.0%	1.6%
Wood	n	1	3	0	0	0	0	4
	%	1.4%	4.2%	0.0%	0.0%	0.0%	0.0%	1.1%
Straw	n	6	15	0	0	0	0	21
	%	8.3%	20.8%	0.0%	0.0%	0.0%	0.0%	5.5%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 6: Support Providing Donor Countries

Donor Countries		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
USA	n	10	13	8	8	25	10	74
	%	38.5%	52.0%	80.0%	44.4%	67.6%	35.7%	51.4%
UAE	n	5	7	2	5	6	0	25
	%	19.2%	28.0%	20.0%	27.8%	16.2%	0.0%	17.4%
France	n	3	0	0	0	0	0	3
	%	11.5%	0.0%	0.0%	0.0%	0.0%	0.0%	2.1%
South Korea	n	3	0	0	0	0	0	3
	%	11.5%	0.0%	0.0%	0.0%	0.0%	0.0%	2.1%
Canada	n	0	0	0	0	0	10	10
	%	0.0%	0.0%	0.0%	0.0%	0.0%	35.7%	6.9%
Saudi Arabia	n	5	5	0	5	6	8	29
	%	19.2%	20.0%	0.0%	27.8%	16.2%	28.6%	20.1%
Total	n	26	25	10	18	37	28	144
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Source: Questionnaire Survey, June-October, 2016

Table 7: Inhabitants Beliefs about Support from Donor Countries in Adverse Situation

Inhabitants Beliefs		Study Unions						Total
		Munshigonj	Gabura	Lalua	Nilgonj	Khurushlkul	Bharuakhali	
Yes	n	33	17	14	8	36	15	123
	%	45.8%	23.6%	24.6%	16.3%	42.9%	32.6%	32.4%
No	n	39	55	43	41	48	31	257
	%	54.2%	76.4%	75.4%	83.7%	57.1%	67.4%	67.6%
Total	n	72	72	57	49	84	46	380
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Chi-Square	χ^2 Value=20.055, df=5, p=0.001							

Source: Questionnaire Survey, June-October, 2016

Table 8: Trend of Tidal Surge in Three Coastal Tide Stations

	Region	Latitude (N)	Longitude (E)	Datum (m)	Trend (mm/year)
Hiron Point	Western	$21^0 48$`	89^0 28`	3.784	4.0
Char Changa	Central	$22^0 08$`	$91^0 06$`	4.996	6.0
Cox's Bazar	Eastern	$21^0 26$`	91^0 59`	4.836	7.8

Source: SAARC Meteorological Research Centre. 2007(All the three points are adjacent to study area)

Table 9: Features of vulnerable districts in the coastal zones of Bangladesh

SL. No.	Name of district	Area (km^2)	Total population*	% of total country population*	Nature of vulnerability		
					Salinity	Tidal surge	Cyclones
1	Barguna	1,832	845,060	0.682	√	√	√
2	Barisal	2,791	2,348,440	1.896	√	√	√
3	Bhola	3,403	1,703,200	1.375	√	√	√
4	Jhalokati	758	692,680	0.559	√	√	√
5	**Patuakhlai**	**3,205**	**1,464,800**	**1.183**	√	√	√
6	Pirojpur	1,308	1,099,780	0.888	√	√	√
7	Bagerhat	3,959	1,516,820	1.225	√	√	√
8	Jessore	2,567	2,469,680	1.994	√		
9	Khulna	4,395	2,357,940	1.904	√	√	√
10	Narail	990	694,900	0.561	√	√	
11	**Satkhira**	**3,858**	**1,845,120**	**1.490**	√	√	√
12	Chandpur	1,704	2,241,020	1.810	√	√	√
13	Chittagong	5,283	6,543,860	5.284	√	√	√
14	**Cox's Bazar**	**2,492**	**1,759,560**	**1.421**	√	√	√
15	Feni	928	1,205,980	0.974	√	√	√
16	Laksmipur	1,458	1,486,540	1.200	√	√	√
17	Noakhali	3,601	2,570,640	2.076	√	√	√
18	Gopalganj	1,490	1,151,800	0.930	√		
19	Shariatpur	1,181	1,080,680	0.873	√	√	
	Total	**47,203**	**35,078,500**	**28.323**			

*Source: BBS, 2011

Table 10: Operated, homestead, cultivated and cropped area

(area in hectares)

SL No.	Name of District	Owner area	Operated area	Homestead area	Net cultivated area	Temporary cropped area
1	Barguna	110546	108168	5236	91370	80587
2	Barisal	194757	190727	38716	151953	128047
3	Bhola	130854	138280	8196	116433	93935
4	Jhalokati	68283	58481	2575	49024	38516
5	Patuakhali	183767	175776	8294	149674	139073
6	Pirojpur	109558	105437	4890	88896	66074
7	Bagerhat	163333	166260	7787	137003	111378
8	Jessore	196056	198783	12357	152744	128049
9	Khulna	178399	143396	11285	108159	97075
10	Narail	81005	79768	4143	65784	58636
11	Satkhira	175687	180676	9502	99540	84899
12	Chandpur	97165	106677	12768	71938	65151
13	Chittagong	255540	236994	36699	150786	136064
14	Cox's Bazar	84804	98153	12665	62395	55377
15	Feni	66875	69000	8024	48065	44706
16	Laksmipur	88790	94794	7443	70743	56466
17	Noakhali	179315	187151	15164	141301	127439
18	Gopalganj	122957	113036	7402	90762	88527
19	Shariatpur	87117	85895	7864	65819	61142
	Coastal total	2574808	2537452	221010	1912389	1661141
	Bangladesh	9539800	9499448	748523	7321267	6730708

Source: BBS, Agriculture Sample Survey-2011.

Table 11: Protected areas in the coastal zone of Bangladesh

Type	Name	Area (ha)	Location	Will 1m SLR affect?
Reserved Forest	-	885,043	Bagerhat, Barguna, Bhola, Chittagong, Cox's Bazar, Feni, Khulna, Lakshmipur, Noakhali, Patuakhali, Satkhira	Yes
National Park	Himchari	1,729	Cox's Bazar	No
	Nijhum Dweep	4,232	Hatiya, Noakhali	Yes
Eco-park	Sitakunda	808	Chittagong	No
Wildlife Sanctuaries	Sundarban East	31,227	Bagerhat	Yes
	Sundarban South	36,970	Khulna	Yes
	Sundarban West	71,502	Satkhira	Yes
	Char Kukri Mukri	2,017	Bhola	Yes
	Chunati	7,761	Chittagong	No
Game Reserve	Teknaf	11,615	Cox's Bazar	No
Ramsar Site	The Sundarbans	601,700	Bagerhat, Satkhira, Khulna	Yes
Environmental Critical Areas	Sonadia	4,916	Cox's Bazar	Yes
	Teknaf beach	10,465	Cox's Bazar	Yes
	St. Martin Island	590	Cox's Bazar	Yes
World Heritage Site	Wildlife Sanctuaries of the Sundarbans		Bagerhat, Satkhira, Khulna	Yes
	Shaat Gombuz Mosque	0.16	Bagerhat	Yes
Marine Reserve		69,800	Bay of Bengal	Yes
Fish Sanctuaries		15,614	Barisal, Bagerhat, Bhola, Patuakhali, Narail, Khulna, Jessore, Lakshmipur, Feni	Yes

Appendix-B1: Household Survey Questionnaire

Questionnaire Number:		District:		Upazila:	
Enumerator's Name:		Thana:		Village:	

Section A: Background Information of Household

Name of Respondent:				Origin:		How Many Years in this village:			
Household Information:				**Religion:**	Muslim	Hindu	Buddhist	Christian	
Member No.	Status (1)	Gender (2)	Age	Marital Status (3)	Education (4)	Reasons of Absent (5)	Causes of School Drop Out (6)	Occupation (7)	
								Primary	Secondary
1									
2									
3									
4									
5									
6									
7									
8									
Other									

Remark:

1. HH Status: 1=Household head, 2=Wife, 3= Husband, 4=Son, 5=Daughter, 6=Father, 7=Mother, 8=Daughter law/Son in law, 9=Brother, 10=Sister, 11=Grandfather, 12=Grandmother, 13= Other (specify)

2. Gender: 1= Male, 2=Female

3. Marital Status: 1=Unmarried, 2=Married, 3=Widow, 4=Divorced, 5=Separated

4. Education: 1=Illiterate, 2=Can read and write, 3. Drop out, 4=Primary school, 5=Secondary school, 5= College, 6= others (specify)

5. Reasons for Absent of HH member: 1=Seasonal labor migration, 2=Education, 3=Staying with family elsewhere, 4=Split up HH

6. Causes of School Dropout: 1. School fees too high, 2. HH need labour, 3. Child Chronically ill or disable, 4. Marriage, 5. Work out side, 6. others

7.Occupation: 0=Unemployed, 1=Agriculture, 2=Share cropper, 3=Agriculture and Share cropper, 4=Agricultural labor, 5=Non-agri labor, 6=Rickshaw/Van puller, 7=Fishing, 8=House helper/maid, 9=Professional (Blacksmith, Cobbler, Carpenter, Sewing, etc.) 10=Petty business (<2000tk), 11=Business, 12=Handicraft, 13=NGO worker, 14=Beggar, 15=Student, 16=House wife, 17=Private/Govt. service, 18=Dependent, 19=Salt producer, 20=Fish fry collector, 21=Fish drying, 22=Fuel wood collector, 23=Fish cultivation (pond/gher), 24=Driver (Mechanized vehicle), 25=Handloom, 26=Others (specify)

Section B: Livelihood Assets

a) Human Capital

a.1 Health status of HH Head	1. Long term illness		2. Disabled	3. Both		4. No
a.2 Ability to work with Adverse Situation	1. None		2. Low	3.Moderate	4. High	5.Very High

a. 3 Do you have any experience in agricultural, fishing or disaster related training program? (Please give× on training)

1. No	2. 1 time	3. 2 times	4. 3 times	5. More than 3 times

a. 4 If you have experience, have you gain any new knowledge on agriculture, fishery or disaster risk reduction? Please give rating

1.None	2. Low	3. Moderate	4. High	5. Very high

a. 5 Leadership Potential: When you face any problem, Can you solve those by yourself?

1. Never	2. Often	3.Very Often	4. Usually	5. Always

a. 6 Have you ever selected or voted as a representative of any group or group's committee

1. Never	2. 1 Times	3. 2 Times	4. 3 Times	5. More than 3 times

a. 7 Have you exposed your idea in the group's meeting

1. Never	2. 1 Times	3. 2 Times	4. 3 Times	5. More than 3 times

a. 8 Have you helped others to solve their problem within the group

1. Never	2. 1 Times	3. 2 Times	4. 3 Times	5. More than 3 times

a. 9 Have you motivated others to participate in community activities

1. Never	2. 1 Times	3. 2 Times	4. 3 Times	5. More than 3 times

a. 10 Have you ever facilitated community and GO-NGO activities?

1. Never	2. 1 Times	3. 2 Times	4. 3 Times	5. More than 3 times

a. 11 Have you solved any conflict in the community?

1. Never	2. 1 Times	3. 2 Times	4. 3 Times	5. More than 3 times

b) Natural Capital b .1 Land Related Information: b.1 Do your household has access to land?

1. Yes	2. No

b. 2 If yes answer the following question

Information of land (in Decimals)	Yes	No	Amount	Owner	Renter
a. Own Homestead Land					
. b. Own Agricultural Land					
c. Own Other Land					
d. Land Share Crop IN					
e. Land Share Crop OUT					
f. Land Lease IN					
g. Land Lease IN					
h. Land mortgage IN					
i. Land mortgage OUT					

* Code for contact: 1. Annual Contact, 2. Seasonal Contact, 3. Other (specify)

b. 3 Pond: Do you have pond or Doba? Yes ☐ No ☐

If yes answer the following question, pond type

1. Productive	2. Unproductive	3. Annual	4. Seasonal

b. 4 Drinking Water: What are the sources of HH drinking water and its distance from house

1. Tube well	2. Pond	3. River	4.Rain water	5. Others (specify)	……	Meter

b. 5 If you drink tube well water, is the tube well arsenic tested?

yes	No	Don't know

b. 6 Do you have access to open water resources such as River or Sea (if any)? Yes No, if yes

1. None	2. Low	3.Moderate	4. High	5.Very High

b. 7 Do you have access to forest to collect fuel wood or other resources (if any)? Yes No, if yes

1. None	2. Low	3.Moderate	4. High	5.Very High

b. 8 Do you have access to open grazing land for fodder (if any)? Yes No, if yes

1. None	2. Low	3.Moderate	4. High	5.Very High

b. 9 Do you have access to Khas land or Char Land (if any)? Yes No, if yes

1. None	2. Low	3.Moderate	4. High	5.Very High

b. 10 Please rate the degree of soil fertility of your agricultural land

1. Do not know	2. Low	3.Moderate	4. High	5.Very High

b. 11 Please mention the trend of soil fertility change over the last 10 years

1.Rapidly decreased	2. Decreased	3. No change	4.Increased	5. Rapidly increased

b. 12 Please mention the sufficiency of water for irrigation

1. Highly insufficient	2. Insufficient	3. Moderately Sufficient	4.Sufficient	5.Highly Sufficient

b. 13 Salinity intrusion in agricultural land

1. None	2. Low	3.Moderate	4. High	5.Very High

b. 14 Please rate the event of tidal surge in your agricultural land

1. Never	2. Rare	3. Sometime	4. Often	5. Always

c) Financial Capital

Stock of money	Cash	Number	Amount	Taka
	Bank deposit			
	Cooperative or Group deposit			
	Remittances			
	Pension			
Liquid Assets	Livestock			
	Storage of rice			
	Poultry			
	Trees			
	Jewelry			
	Furniture's			
	Others			

d) Physical Capital:

d. 1 House Type

a. Wall		c. Roof		c. Floor	

Code for housing material: 1=Pucca /Brick, 2= Kancha/dirt, 3=Tin, 4=Bamboo, 5=Wood, 6=Straw, 7=Tiles, 8= Others (Specify)

d. 2 Do you have electricity connection in your house?

1. Yes	2. No	Solar	Public	Generator

d. 3 Type of latrine ☐

1. Pit latrine, 2. Sanitary/ring slab, 3. Pucca (water sealed), 4. Pucca (un-hygienic), 5. Open defecation, 6. Hanging, 7. Others

d. 4 where do household members usually defecate?

a) Adult male b) Adult female C) Children

1. Pit latrine, 2. Sanitary/ring slab, 3. Pucca (water sealed), 4. Pucca (un-hygienic), 5. Open defecation,

6. Hanging, 7. Others

d. 5 Access to road network to reach market

1.Very poor	2. Poor	3. Moderate	4. Good	5.Very Good

d. 6 Distance of Market from house ------------- k. m. and means of transportation------ Means**

Means**Means of transportation: 1. Rickshaw/Van, 2. Karimon and Nosimon, 3. Bicycle, 4. Mechanized boat, 4. Boat, 6. others.

d. 7 Have any access to Cyclone Shelter and its distance? Yes No if yes, Distance K. m.

d. 8 If yes please mention the degree of access

1.Very poor	2. Poor	3. Moderate	4.Good	5.Very Good

d.9 Ownership and Access to Machineries

Machinery	Ownership	Unit	Price (Tk)	1.Very Poor	2. Poor	3. Moderate	4. Good	5.Very Good
Tractor	Y/N							
Harvester	Y/N							
Boat for Fishing	Y/N							
Net for Fishing	Y/N							
Rickshaw/Van	Y/N							
Motorbike	Y/N							
Bicycle	Y/N							

d.9 If you do not have access to such items then how do you work?

1. Rent	2. Manual	3. Borrow	4. Others

e) Social Capital: Access to Information

e. 1 Please give tick for assessing disaster information dissemination by mass communication

Access to Mass communication		**Frequency of access to information**				
	Access	No Access	<once a month	Once a Month	2-4 Days in a Month	> 4 days in Month
Radio	Y/N					
Television	Y/N					
Newspaper	Y/N					
Printed	Y/N					
Radio	Y/N					
materials/leaflet						

e. 2 Please give tick for assessing individual communication

Access to individual **communication**	**Frequency of access to information**					
	Access	No Access	<once a month	Once a Month	2-4 Days in a Month	> 4 days in Month
Disaster Mitigation Worker						
Agriculture Extension Worker						
Fishery Department Worker						
Health and family Planning(w)						
Union Parishad NGOs/CBOs						

c.3 Participation and Connection? yes No

If yes, Please mention frequency of your participation in community based awareness programs

1. Never	2. Rarely	3.Sometime	4. Often	5. Always

e. 4 Please mention frequency of your participation in activities or meeting for disaster mitigation or other activities in community

1. Never	2. Rarely	3.Sometime	4. Often	5. Always

e.5 Do you have communication or network with NGOs and other Voluntary organizations, who works for disaster risk reduction?

1. Never	2. Rarely	3.Sometime	4. Often	5. Always

e. 6 What is the relationship of your HH with other within the community?

1. No	2. In some extent	3. Moderate	4. Good	5. Very Good

e. 7 Do you assist each other in your community during crisis or adversity?

1. Never	2. Rarely	3. Sometimes	4. Often	5. Always

e. 8 Please mention your status in the following groups

Group in Community	Membership	No Membership	Member but low participation	Member with moderate participation	Member with high participation	Member in core committee
Voluntary group	Y/N					
Religious group	Y/N					
Micro-credit	Y/N					
Cooperative	Y/N					
Closely associated with	Y/N					

Section C: Livelihood Strategies

d. 1 What are the major sources of your Household Income?

Major Sources of Income Field Crop (Own + Lease + Mortgage)	Income in Taka (HH	Income (Other Members)	Availability (Months/Year)	Rank according to
Share Crop				
Homestead Crop				
Agriculture Labor				
Non-ag. Wage Labor				
Rickshaw/Van puller				
Fish fry collection				
Fishing in open water				
Fish culture (project)				
Betel nut production				
Coconut production				
House helper (maid)				
Classified profession (Cobbler,				
Barber etc.)				
Petty business				
Business				
Handicraft				
Livestock rearing				
Poultry rearing				
Urban remittance				
International Remittance				
Service				
Urban remittance				
International Remittance				
Service				
Money lending				
VGD/FFE/Old age pension				
Begging				
Others (Specify)				

c. 2 Do you remain unemployed any time in a year? Yes No

If yes please mention the following answer

Month/Season	**Reasons**	**Type of work performed**
1	1	1
2	2	2
3	3	3

c.3 Please mention the Household Annual Expenditure on Major Items

Area of Expenditure	Unit cost	No of unit	Total cost/yr
House rent/month			
House repairing/year			
Food/month			
Entertainment/month			
Others (specify)			
Health/month			
Cloth/yr			
Loan repayment/month			
Agricultural inputs/yr			
Boat repairing/yr			
Livestock, poultry/yr			
Social religious occasions/yr			
Entertainment/month			
Others (specify)			

c.4 Savings

Do you have any savings? Yes ☐ No If yes what is the amount? ☐ Taka

Have you used the money in last years that you saved? Yes No ☐

If yes in which purpose you invested for? ☐ Purpose ☐ Amount

1. Education, 2. Health, 3. Loan repayment, 4. Ag. Inputs, 5. Fishing Instruments, 6. Housing, 7. Clothes, 8. Food, 9. Dowry. 10. Festival, 11. Buying Luxury items, 12. Business, 13. Livestock/Poultry, 14. Land purchase 15. Others

c. 5 Credit

Do you have any loan or borrowed money in last 2 years? Yes No

If yes when you Before during After crisis

Please mention the sources of credit?

Sources	**Amount**	**Purpose of taking loan and Amount in Tk.**			**Amount**
Mahajan/Money lender		Farming		Poultry	
NGOs		Health		Livestock	
Friends/Relatives		Marriage		Business	
Bank		Housing		Buy productive assets	
Grameen Bank		Dowry		Loan repayment	
Govt. (BRDB, Youth Ministry etc.)		Emergency		Land purchase	
Arotdars		Food cosumption		other(specify)	
Others (specify)		Fishing			

c.6 Have you applied this money for this mentioned purpose? Yes No

If no why and where you have used this money? a. ----- d. ------- c. -------

c. 7 Adversity or Crisis

What kind of main crisis or Livelihood risk you have experienced in last couple of years? (Mostly focus on natural calamities)

1. Cyclone	6. Loss of Trees
2. Storm surge	7. Loss of Ag. Production
3. Flood	8. Loss of fish production
4. Riverbank erosion	9. Illness
5. Salinity	10. Others (Specify)

Section D: Impact of Climate change Induced Sea Level Rise

d.1 Familiarity with and Knowledge about CCSLR phenomena

CCSLR phenomena	1	2	3	4	5
1. Longer duration of summer					
2. Summers are felt warmer than earlier					
3. Shorter duration of winter					
4. Winters are felt less cold than earlier					
5. Winter starts late than the normal timing					
6. Unusual formation of fog in the winter is higher than earlier					
7. Very hard to distinguish 6 seasons of a year now than any time earlier					
8. Untimely rainfalls are becoming more prevalent than earlier					
9. Overall rainfall are decreasing than earlier					
10. Water of river, canal are getting more saline than earlier					
11. Frequency of stormy events are increasing than earlier					
12. Encroachment of new areas by high tide					
13. Migratory birds are less seen in winter than earlier					
14. Winter starts late then earlier					
15. Timely rainfall are very rare					

1	2	3	4	5
Not informed	Very Slightly Informed	Slightly Informed	Informed	Strongly Informed

d. 2 Did anybody tell you or you heard about:

1. Sea level is rising		
2. Coastline will shift inward in the future due to SLR		
3. Part of your low land, farmland even homestead may go gradually under water forever		
4. New areas, even your farm land will be under saline/brackish water		
5. Frequency and magnitude of storm surge will increase and affect your livelihood		
6. Getting salt free/sweet water for drinking will be difficult		
7. Coastal erosion will engulf everything		

1	2	3	4	5
Not informed	Very Slightly Informed	Slightly Informed	Informed	Strongly Informed

d. 3 From whom you have taken information about CCSLR

surveyor	
Educated person	
NGO worker	
Govt. Employee	
Newspaper	
Radio	
Television	
Talk show	

d. 4 Your perception about probable impact of SLR

1. New areas under water					
2. Permanent inundation of covering large area **(-)**					
3. Temporary inundation of covering large area **(-)**					
4. Increase in basin for higher storm surge **(-)**					
5. Increase soil salinity **(-)**					
6. Increase surface water salinity **(-)**					
7. Inward migration of Mangrove forest **(-)**					
8. Loss of agricultural land **(-)**					
9. Loss of pasture **(-)**					
10. Damage of nonfarm economic activity **(-)**					
11. Damage of human settlements **(-)**					
12. Damage of Economic infrastructure **(-)**					
13. Damage of Social Institutions **(-)**					
14. Scarcity in source of potable water **(-)**					
15. Loss of production in crop agriculture & horticulture **(-)**					
16. Loss of production in livestock **(-)**					
17. Loss of complementary/supplementary income **(-)**					
18. Restricted physical mobility of people, goods & services **(-)**					
19. Limited social interaction and mobility of people **(-)**					
20. Prevalence of Waterborne disease **(-)**					
21. Threatened food security **(-)**					
22. Drop in household total income **(-)**					
23. Increase in household expenditure **(-)**					
24. Environmental degradation, health hazard & increased cost for medication **(-)**					
25. Disrupted & unsecured livelihood **(-)**					
26. High pressure on limited safer area nearby to accommodate migrants likely to be forced to evacuate **(-)**					
27. Sea Level Rise Refugee **(-)**					

1	2	3	4	5
No possibility	low Possibility	May be or not	Possibility	Strong Possibility

Understanding/Knowledge about the potential positive impact of SLR

1. Suitability of land for aquaculture (shrimp) **(+)**		
2. Intensification of commercial shrimp farming **(+)**		
3. Inward spreading/ shifting/migration of mangrove forest (+)		
4. Increase of natural defense against cyclonic effect **(+)**		
5. Forest based new livelihood **(+)**		

1	2	3	4	5
No possibility	low Possibility	May be or not	Possibility	Strong Possibility

Section E: Strategies for Adaptation to Mitigate Sea Level Rise Impact

e.1 Please mark the causes of SLR

Global temperature change	Low lying coastal area	Adjacent to sea	Rainfall increasing	Others

e.2 Please mention the degree of risks of livelihood security due to sea level rise

Very high	High	Medium	Low	Very Low

e. 3 Please mention the vulnerable sector due to sea level rise

Residence	Food	Employment	Communication	Health	Education

e. 4 What are the adaptation strategies regarding Low land, agricultural land, residence to face adverse situation due to SLR

present management	Strategies for upcoming adverse situations		
	2030 (In case of 14 cm SLR increase)	2050 (In case of 32 cm SLR increase)	2100 (In case of 88 cm SLR increase)
a. Residence on high land b. Cultivation in less saline area c. Salinity tolerant rice/crops d. Nonfarm occupation e. Unknown	a. Building residence on high land b. Select less saline area for agriculture c. Change of occupation d. Selling property e. Unknown f. Others	a. Highland for dwelling b. Involve in Nonfarm economy c. Selling property and settled in other placers d. Others e. Unknown	a. Finding safe place b. Settled in big town for employments c. Change profession d. Others e. Unknown

e.5 What are the adaptation strategies regarding Agricultural activities to face adverse situation due to SLR

present management	Strategies for upcoming adverse situations		
	2030 (In case of 18ds/m Salinity increase)	2030 (In case of 20ds/m Salinity 2030 (In case of 18ds/m Salinity increase) increase)	2030 (In case of 25ds/m Salinity increase)
a. Common crops b. Change in land management c. Proper irrigation d. Others	a. Flood and salinity tolerant crops b. Selection of cropping period c. Change of cultivation techniques d. Others	a. High yielding crops b. High saline tolerant crops c. Change of cultivation time d. Others	a. Aqua culture b. Highly flood and saline tolerant crops c. Others d. Unknown

e.6 Changes in cropping pattern in Salinity intrusion

present management	Strategies for upcoming adverse situations		
	2030 (In case of 14 cm SLR increase)	2050 (In case of 32 cm SLR increase)	2100 (In case of 88 cm SLR increase)
a. Local variety rice (BR 10.11.12, BRRI-28,30) b. Purbaci, Jamaibabu etc. c. Vegetables, Fruits	a. BBRI-41,49 b. Lal teer,Khajalata,China c. Bari Mog-5 d. New saline tolerant crops	a. BBRI-40,47 b. Hybreed Hira, saheeb kuchi,Malagati, Sahebktal, Bina c. BIna-78,98 d. New saline tolerant crops	a. kajosile, Hammi, Nonakuchi b.Durgavog c.Highly saline tolerant Crops d.Unknown

e. 7 Land use adaptation strategies in terms of sea level rise

Present management	Strategies for upcoming adverse situations		
	2030 (In case of 14 cm SLR increase)	2050 (In case of 32 cm SLR increase)	2100 (In case of 88 cm SLR increase)
a. Crops b. Prawn c. Vegetables, Fruits d. Fresh water fish e. Livestock	a. Saline tolerant crops b. Fresh water fish to Prawn c. Homestead vegetables d. Saline tolerant forests	a. High saline tolerant crops b. Embankment Agriculture c. Prawn cultivation in more space d. Mangrove e. Use of fellow land f. saline tolerant grass foe cattle	a. Prawn in More space b. Floating Dap cultivation c. Golpata, Keora etc.cultivation d. Use of fellow land e. Unknown

e.8 Economic activities adaptation strategies in terms of sea level rise

Present management	Strategies for upcoming adverse situations		
	2030 (In case of 14 cm SLR increase)	2050 (In case of 32 cm SLR increase)	2100 (In case of 88 cm SLR increase)
a. Agriculture b. Fisheries/ Prawn c. NGO d. Livestock e. Business	a. Business b. Poultry/Livestock c. Fisheries/Prawn d. Transportation sector e. Forests	a. Integrated agriculture b. Local and sea fish c. Forestry d. Worker in Brickfields e. Unknown	a. Homestead agriculture b. labor c. Fishing in river and sea d. Golpata, Keora cultivation e. Unknown

e. 9 Livestock management adaptation strategies in terms of sea level rise

Present management	Strategies for upcoming adverse situations		
	2030 (In case of 14 cm SLR increase)	2050 (In case of 32 cm SLR increase)	2100 (In case of 88 cm SLR increase)
a. Homestead grazing land b. Local variety of animal c. Normal management d. others	a. change of grazing land b. Local tolerant animal c. Management change d. Others	a. Uses of fellow land b. New variety c. Others d. Unknown	a. Uses of high land b. High yielding animal c. Selling of own animal d. Others e. .Unknown

e.10 Livestock management adaptation strategies in terms of sea level rise

Present management	Strategies for upcoming adverse situations		
	2030 (In case of 14 cm SLR increase)	2050 (In case of 32 cm SLR increase)	2100 (In case of 88 cm SLR increase)
a. Homestead grazing land b. Local variety of animal c. Normal management d. others	a. change of grazing land b. Local tolerant animal c. Management change d. Others	a. Uses of fellow land b. New variety c. Others d. Unknown	a. Uses of high land b. High yielding animal c. Selling of own animal d. Others e. .Unknown

e.11 Fisheries management adaptation strategies in terms of sea level rise

Present management	Strategies for upcoming adverse situations		
	2030 (In case of 14 cm SLR increase)	2050 (In case of 32 cm SLR increase)	2100 (In case of 88 cm SLR increase)
a. Uses of local pond, river etc. b. Local variety of fish c. Common management d. Others	a. Local and open water for cultivation b. Local tolerant fish c. Change of time of cultivation d. Change of management e. Others	a. Use of risk free shallow water b. salinity tolerant fish c. Change of time d. Change of management e. Others	a. Highly salinity tolerant variety of fish b. Change of reservation. marketing c. Change of Techniques of fishing d. Unknown

e. 12 Nonfarm activities management adaptation strategies in terms of sea level rise

Present management	Strategies for upcoming adverse situations		
	2030 (In case of 14 cm SLR increase)	2050 (In case of 32 cm SLR increase)	2100 (In case of 88 cm SLR increase)
a. Common production method b. Common Reservation method c. Common marketing d.others	a. Common production b. Common safe reservation c. Safe Marketing d. others	a. New method in production b. New method in preservation c. Safe transportation d. Others	a. Raw material in production to change b. Safe reservation c .Change in transportation d. Unknown

e.13 Dwelling places management adaptation strategies in terms of sea level rise

Present management	Strategies for upcoming adverse situations		
	2030 (In case of 14 cm SLR increase)	2050 (In case of 32 cm SLR increase)	2100 (In case of 88 cm SLR increase)
a. Usual place b .Raising platform c. Plantation around the house d. Normal management e. others	a. Main platform to be raised b. Safe place c. Change in construction material d. Management to be changed e. others. f. Unknown	a. Raising platform in more height b. Safe area c. Structural change d. Plantation Around the house e. oters	a. Raise main platform in more height b. Change structure of house c. Change in construction material d. Others e. Unknown

e.14 Do you think that sea level rise will make the local people poor to poorer? Yes No

If yes, who are they?

a. Marginal income holder	b. Land less farmer	c. Medium income holder

e.15 Do you think migration will be the alternative solution for livelihood? Yes No

If yes, who are they?

a. Marginal income holder	b. Land less farmer	c. Medium income holder

If migration takes place, where it will be?

a. Other places	b. Distant village	c. Urban area	d. Other

e.16 What will be the alternative suggestion to help people staying in locality instead of migration?

a. b. c.

a. Necessary information for safe shelter b. Safe keeping of necessary goods c. Safety for live stock d. possible planning for facing disasters e. proper planning for crop production f. Raise pond side to protect saline water for fish culture g. Savings planning for lean period h. Social security establishment i. Enhancing Relationship with others j. Others(Specify)

e.17 What are your suggestions for sustainable livelihood security to face sea level rise adversity?

2030 (In case of 14 cm SLR increase)	2050 (In case of 32 cm SLR increase)	2100 (In case of 88 cm SLR increase)
a. program for enhancing consciousness b. New method for agriculture, forestry, Fisheries, livestock etc. c. Arrangement of drinking water for less expense d. Training for social bonding enhancement e. Others	a. Various program for consciousness b. New method for agriculture, forestry, Fisheries, livestock etc. c. Less expensive drinking water d. Social unity strengthening e. Participation social insurance and security f. Others	a. Training for self replacing, rescue rehabilitation b. New method for agriculture, forestry, Fisheries, livestock etc. c. Easy loan d. Govt. cash subsidy in disaster prone area e. Less expensive drinking water f. Social unity strengthening g. Others

e. 18 What will be the steps of GOs and NGOs for upcoming sea level rise scenario?

Present management	Strategies of GOs and NGOs for upcoming adverse situations		
	2030 (In case of 14 cm SLR increase)	2050 (In case of 32 cm SLR increase)	2100 (In case of 88 cm SLR increase)
a. Extension of Prawn culture b. Agricultural production planning c. Easy loan d. Management of water and soil testing e. Consciousness program	a. Saline tolerant seeds b. Land allocation system c. Proper activities of WAPDA d. Crops insurance e. Coastal adaptation	a. Food and seed collection management b. Embankment management c. Sluice gate management d. Enhancing national consciousness e. Integrated coastal management	a. Water for irrigation b. Coastal forestry c. Development of infrastructure d. GOs and NGOs cooperation e. Sustainable agricultural development planning f. others

e.19 What will be the steps for over all livelihood security adaptation for upcoming sea level rise adversity?

2030 (In case of 14 cm SLR increase)	2050 (In case of 32 cm SLR increase)	2100 (In case of 88 cm SLR increase)
a. Use rain water for drinking and agriculture b. Employment through prawn culture c. Forestry an gardening d. Saline tolerant crops e. Land use with proper consciousness	a. Embankment agriculture b. Fisheries as man livelihood c. Salinity controlling by building embankment d. Raising House platform e. forestry	a. Floating Dhap cultivation b. Saline tolerant mangrove c. Living in floating Boat d. Depending on Sundarbans for livelihood e. Others

Section F: Role of Support Services and their influences on Livelihood and Coping with SLR

f. 1 Agricultural Extension

Did you ever participate in Agricultural extension training program in last 12 months? Yes No

If yes, please mention the name of programs

Did they provide any loan for cyclone damage recovery? Yes No

If yes, mention the amount you got? Taka

Did they provide seed, fertilizer and other agricultural inputs after disaster? Yes No

If yes please mention the amount you got (in Kg.) Seed Fertilizer Pesticide Others

f. 2 Please mention your level of satisfaction on provided service and information by Agricultural extension worker

Highly dissatisfied	Dissatisfied	Moderately satisfied	Satisfied	Highly satisfied

f. 3 Fishery, Livestock and Poultry related services

Did you participate any training program on fishery, livestock and poultry management in last 12 months? Yes No

If yes, please mention the name of programs

Did you get any loan for these purpose? Yes No

If yes please mention the amount you got Taka

Please mention your level of satisfaction on provided service and information by Agricultural extension worker

Highly dissatisfied	Dissatisfied	Moderately satisfied	Satisfied	Highly satisfied

f 4 If you never participated in Agriculture, Fishery or Livestock related training programs, please mention the reason

1. No information	4. Too expensive to participate (transportation and other
2. Not necessary	5. Not ready for training because too old
3. No opportunity because of business	6. Others (specify)

f.5 Other Organizations and their activities

Did any organization disseminate knowledge about SLR? Yes No

If yes, mention the name a. BRDB, b. PROSIKA, c. BRAK, d. CARE, e. CARITAS, f. SAVE THE CHILDREN, g. Public health Dept, h. Other (Specify)

f.6 Did any foreign countries disseminate knowledge about SLR? Yes No

If yes, mention the name a. USA, b. SAUDIA ARABIA, c. FEANCE, d. SOUTH KOREA e. Other (Specify)

Will they provide any support to face adverse situation? Yes No

Did you get any training from them? Yes No

f.7 Please mention your satisfaction level about their activities

Highly dissatisfied	Dissatisfied	Moderately satisfied	Satisfied	Highly satisfied

Section G: Livelihood Outcomes

g. 1 Food Security

Number of months HH has adequate food to feed all members? ---------- Months

Number of months HH can eat adequate vegetable (own production and purchase)? --------- Months

No of Meals consume per day usually? Amount of Rice(All member) Kg.

No of Meals consume per day in lean period? Amount of Rice(All member) Kg.

g. 2 How many days in a weak your HH take Following food items

Food Items	Days in a weak	Amount
Pulses		
Vegetables		
Potato		
Fish		
Egg		
Fruits		
Milk		
Meat		
Soyabean oil		
Mustered oil		
Others		

g.3 Food Intake History of Past 24 Hours (3 meals)

Item	Morning	Noon	Night
1			
2			
3			
4			
5			
6			

g.4 Do you think quantity of food your HH consume usually is adequate? Yes No

If not mention your level of satisfaction

Highly dissatisfied	Dissatisfied	Moderately satisfied	Satisfied	Highly satisfied

g.5 Do you think quality of food your HH consume usually is adequate? Yes No

If not mention your level of satisfaction

Highly dissatisfied	Dissatisfied	Moderately satisfied	Satisfied	Highly satisfied

g.6 Do you have any anxiety or uncertainty about the budget you have to meet the future food requirement? Yes No

If yes mention the level of anxiety

Very low	Low	Moderate	High	Very High

g.7 Nutritional Security

Stunting and wasting among children 6-59 months.

Age		Years
Height		Feet
Weight		Kg.

g.8 Body Mass index of women of reproductive age (mothers 14-50 years)

Height		Feet
Weight		Kg

g.9 Sanitation Security

What type of latrine do you use? Type of latrine------

1. Pit latrine, 2. Sanitary/ring slab, 3. Pucca (water sealed), 4. Pucca (un-hygienic) 5. Open defecation, 6. Hanging 7. Others

Where do household members usually defecate?

a) male		b) female		c) Children	

1. Pit latrine, 2. Sanitary/ring slab, 3. Pucca (water sealed), 4. Pucca (un-hygienic), 5. Open defecation, 6. Hanging 7. OthersDo you think that sanitation system is sufficient? Yes NoIf yes please mention the satisfaction level of sanitation system

Highly dissatisfied	Dissatisfied	Moderately satisfied	Satisfied	Highly satisfied

g.10 Education Security

Do you have any school nearer to house? Yes No

If yes mention the distance of school-------------- km.

How many members of 7+ can read and write?

How many male members of 15+ are educated?

How many female members of 15+ are educated?

How many older members of 10+ are educated?

How many member of 6-10 age are educated?

Do you get any educational subsidy for education? Yes No

If yes please mention the name of source----------

Please mention the satisfaction level of present education system

Highly dissatisfied	Dissatisfied	Moderately satisfied	Satisfied	Highly satisfied

g.11 Health Security

Do all the children's of your household have given immunization? Yes No

If no, please mention the causes…………………………………………………………

Please mention any child in your HH died during birth or within five years of birth?

If yes mention the causes of death…………………………………………………………………….

Health Status of Household members in last 1 month

Types of illness	Number of Days in last 1 month -illness and missed work days							
	Male		Female		Boy		Girl	
	Illness days	Missed Working Days	Illness days	Missed Working Days	Illness days	Missed Working Days	Illness days	Missed Working Days
a) Diarrhea								
b) Cold/Fever								
c) Skin Disease								
d) Dysentery								
e) Operation								
f) Other Diseases								

Amount spent in last month for medicine and fees (Tk.)---What was healthcare Expenditure 1 Year ---------

If there is any seasonal variation in incidence of these diseases, please mention the which disease is higher in which season……Please mention the Incidence of general diseases in your Household

Increased Decreased Same as previous year

Have you or your HH members visited any medical facility in last 2 years? ☐ Yes ☐ No

If yes, mention the facilities you or your HH members have visited ☐

1=Kobiraj, 2=Village doctor, 3=Homeopath, 4=Medicine shop, 5=Thana Health Complex, 6=District Hospital, 7=Private MBBS, 8=NGO clinic/worker, 9=Community clinic, 10=Others(specify)Please mention the time period of visiting ……………………………………………..Months Please mention your satisfaction on the behavior level of doctor or others, and the level of effectiveness of treatment

Source of treatment	Strongly Dissatisfied	Satisfied	Moderately Satisfied	Satisfied	Highly Satisfied

Please mention the effectiveness of treatment

Source of treatment	Not effective	partially effective	Moderately effective	Effective	Highly Effective

Appendix B2. Check List for GOs and NGOs Interview

Institute of Bangladesh Studies, University of Rajshahi, Rajshahi
Interview Schedule (GOs and NGOs Employed in Coastal Area)
(Potential Impact of Climate Change Induced Sea Level rise on Livelihood security in Coastal Bangladesh)
(Your Information will be Used Only for Educational Research)

Questionnaire No-	Dist-		Upazilla-
Name of interviewer-	P. S.	Vill-	

a. General information

1. Name of Respondent
2. Name of Institution
3. Designation
4. Mobile No

b. Familiarity with and Knowledge about CCSLR phenomena

CCSLR phenomena	1	2	3	4	5
1. Longer duration of summer					
2. Summers are felt warmer than earlier					
3. Shorter duration of winter					
4. Winters are felt less cold than earlier					
5. Winter starts late than the normal timing					
6. Unusual formation of fog in the winter is higher than earlier					
7. Very hard to distinguish 6 seasons of a year now than any time earlier					
8. Untimely rainfalls are becoming more prevalent than earlier					
9. Overall rainfall are decreasing than earlier					
10. Water of river, canal are getting more saline than earlier					
11. Frequency of stormy events are increasing than earlier					
12. Encroachment of new areas by high tide					
13. Migratory birds are less seen in winter than earlier					
14. Winter starts late then earlier					
15. Timely rainfall are very rare					

1	2	3	4	5
Not informed	Very Slightly Informed	Slightly Informed	Informed	Strongly Informed

c. Please mark the causes of SLR

Global temperature change	Low lying coastal area	Adjacent to sea	Rainfall increasing	Others

d. Please mention the degree of risks of livelihood security due to sea level rise

Very high	High	Medium	Low	Very Low

e. Please mention the vulnerable sector due to sea level rise

Residence	Food	Employment	Communication	Health	Education

f. Your perception about probable impact of SLR

1. New areas under water					
2. Permanent inundation of covering large area **(-)**					
3. Temporary inundation of covering large area **(-)**					
4. Increase in basin for higher storm surge **(-)**					
5. Increase soil salinity **(-)**					

6. Increase surface water salinity **(-)**					
7. Inward migration of Mangrove forest **(-)**					
8. Loss of agricultural land **(-)**					
9. Loss of pasture **(-)**					
10. Damage of nonfarm economic activity **(-)**					
11. Damage of human settlements **(-)**					
12. Damage of Economic infrastructure **(-)**					
13. Damage of Social Institutions **(-)**					
14. Scarcity in source of potable water **(-)**					
15. Loss of production in crop agriculture & horticulture **(-)**					
16. Loss of production in livestock **(-)**					
17. Loss of complementary/supplementary income **(-)**					
18. Restricted physical mobility of people, goods & services **(-)**					
19. Limited social interaction and mobility of people **(-)**					
20. Prevalence of Waterborne disease **(-)**					
21. Threatened food security **(-)**					
22. Drop in household total income **(-)**					
23. Increase in household expenditure **(-)**					
24. Environmental degradation, health hazard & increased cost for medication **(-)**					
25. Disrupted & unsecured livelihood **(-)**					
26. High pressure on limited safer area nearby to accommodate migrants likely to be forced to evacuate **(-)**					
27. Sea Level Rise Refugee **(-)**					

1	2	3	4	5
No possibility	low Possibility	May be or not	Possibility	Strong Possibility

g. Strategies for adaptation to mitigate sea level rise impact

1. What are the adaptation strategies regarding Low land, agricultural land, residence to face adverse situation due to SLR
   a. b. c. d.
2. What are the adaptation strategies regarding Agricultural activities to face adverse situation due to SLR
   a. b. c. d.
3. Changes in cropping pattern in Salinity intrusion
   a. b. c. d.
4. Land use adaptation strategies in terms of sea level rise
   a. b. c. d.
5. Economic activities adaptation strategies in terms of sea level rise
   a. b. c. d.
6. Livestock management adaptation strategies in terms of sea level rise
   a. b. c. d.
7. Livestock management adaptation strategies in terms of sea level rise
   a. b. c. d.
8. Fisheries management adaptation strategies in terms of sea level rise
   a. b. c. d.
9. Nonfarm activities management adaptation strategies in terms of sea level rise
   a. b. c. d.
10. Dwelling places management adaptation strategies in terms of sea level rise
    a. b. c. d.

Thank you for giving your valuable time

Name and Signature of the interviewer

APPENDIX B3 List of participants in Focus Group Discussion (FGD)

Study Areas (Union)											
Munshigonj		**Gabura**		**Nilgonj**		**Lalua**		**Khurushkul**		**Bharuakhali**	
Place: House of Naser		Place: House of Jalal		Place: House of Jafor		Place: House of Majed		Place: House of Rashid		Place: House of Sohel	
Date: 13/08/2016		Date:14/08/2016		Date: 24/08/2016		Date: 25/08/2016		Date: 2/9/2016		Date:5/9/2016	
1	Joshim	1	Asiaa	1	Jafor	1	Ibrahim	1	Ethan	1	Shahnur
2	Shahabuddin	2	Pushpo	2	Motleb	2	Jalal	2	Ching	2	Ambia
3	Asma	3	Forida	3	Milon	3	Shahjalal	3	Utha	3	Halima
4	Sajeda	4	Fatema	4	Jafor	4	Majed	4	Ching	4	Rehena
5	Minara	5	Mojibor	5	Momotaj	5	Kalam	5	Chen	5	Laili
6	Nasima	6	Jalal	6	Jesmin	6	Monsur	6	Mong	6	Shafiq
7	Naser	7	Rehena	7	Noyontara	7	Alam	7	Kamal	7	Sohel
8	Sofura	8	Morsheda	8	Rahela	8	Rajen	8	Solemon	8	Kamal
9	Milon	9	Jalal	9	Morsheda	9	Eunus	9	Alamgir	9	Jakir
10	Md. Hossain	10	Manik	10	Jahanara	10	Ayesh	10	Rashid	10	Shafiq
11	Selim	11	Kabir	11	Moktar	11	Bibi	11	Alauddin	11	Sohel
12	Eunus	12	Liton	12	Faruk	12	Joynob	12	Dilu Kha	12	Firoja

Appendix C: NGOs Working in Study Area

Serial no.	Organizations Name	Project Area	Types of Works
1	Abash	Lalua Union	Build community for disaster reduction,
		Gabura Union	Community based awareness raising meeting
			For climate change and disaster reduction purpose.
			Skill development of farmer by training., Emergency relief help, agriculture sector by distributing
			improved variety of seed, fertilizer and sharing
			improved cultivation method.
2	Polli Gono Unnoyon Kendro	Nilgonj Union	Community based awareness raising meeting for
			climate change and disaster reduction purpose. Emergency relief help.
3	World Concern	Lalua Union	Disaster preparedness and risk reduction skill
		Munshigonj Union	development., Emergency relief help.
			Agricultural Assistance
4	JJS	Lalua Union	Community based awareness raising meeting for
		Nilgonj Union	climate change and disaster reduction purpose.
			Emergency relief help.
			Agricultural Assistance, Forestation
5	Friendship	Munshigonj Union	Community based awareness raising meeting for
			climate change and disaster reduction purpose.
			Emergency relief help, Agricultural Assistance
			Forestation
			Live and livelihood Assistance for fishermen community.
6	Speed Trust	Lalua Union	Community based awareness raising meeting
		Khurushkul Union	for climate change and disaster reduction purpose.
			Skill development training, meeting, seminar, workshop
			Emergency relief help.
			Live and livelihood Assistance.
7	Wave Foundation	Lalua Union	Community based awareness raising meeting
		Gabura Union	for climate change and disaster reduction purpose.
			Skill development training, meeting, seminar, workshop.
			Emergency relief help, Live and livelihood Assistance.
8	Action Aid	Lalua Union	Community based awareness raising meeting
		Gabura Union	for climate change and disaster reduction purpose
		Bharuakhali	Skill development training, meeting, seminar, workshop.
			Emergency relief help, Life and livelihood Assistance.
9	CARITAS	Lalua Union, Bharuakhali Khurushkul Union	Cyclone/ flood shelter
(Source: Respective Upazila Office, 2016)			

Appendix D: Photograph


Houses with Raised Platform (source: Field survey, 2016).


Raised Platform of Sanitary Latrine and Community Tube well in Khurushkul Union
(Source: Field survey, 2016)


Homestead Gardening and Livestock Rearing in Lalua Union (Source: Field survey, 2016)


Raising the Boundary of Pond for Fish Culture in Lalua Union (source: Field survey, 2016)

Cyclone Centre cum Primary School in Lalua and Khurushkul Union
(Source: Field survey, 2016)

River Bank Erosion in Lalua Bharuakhali Union (Source: Field survey, 2016)

FGD Session in Khurushkul and Lalua Union (source: Field survey, 2016)

Male and Female headed Household in Bharuakhali and Nilgonj Union
(Source: Field survey, 2016)

Lean Period Activities in Coastal Area (Source: Field survey, 2016)

Activities of Foreign and Local Organization (source: Field survey, 2016)

Livelihood option as Fisheries and Crab Farming Activities
(Source: Field survey, 2016)

Livelihood Option as Agriculture and Salt Farming Activities
(Source: Field survey, 2016)

Immunization Centre in Nilgonj and Gabura Union (source: Field survey, 2016)


Coastal Water logging (Source: Field survey, 2016)


Livelihood Activities as Forestry in Coastal Area (Source: Field survey, 2016)


Top Dying of Sundari Tree Due to Salinity in Gabura Union
(Source: Field Survey, 2016)

Fish Fry collecting and Selling Locally in Lalua Union
(Source: Field survey, 2016)

Staying Near the Coast to Keep Safe from Hostile Sea.
(Source: Field survey, 2016)

Road Network in Gabura Union (Field Survey, 2016)

Toilet Facilities and Housing in Lalua Union Union (Field Survey, 2016)

Bibliography

Books

Ahsan, Rosie Majid and Hafiza Khatun, eds. *Disaster and the Silent Gender*. Dhaka: Bangladesh Geographical Society, 2004.

Baqee, Abdul. *People in the Land of Allah Janne*. Dhaka: UPL, 1999.

Brammer. H. *Agriculture Disaster Management in Bangladesh*. Dhaka: UPL, 1999.

Brammer. H. *The Physical Geography of Bangladesh*. Dhaka: The University Press Limited, 2012.

Bryant, E.A. *Natural Hazards*. London: Cambridge University Press, 1991.

Carney, D. "Implementing the Sustainable Rural Livelihoods Approach." in: *Sustainable Rural Livelihoods – What Contribution Can We Make?* Carney, D. (ed.). London: Department for International Development, 1998.

Chambers, Robert and Gordon Conway. *Sustainable Rural Livelihoods: Practical Concepts for the 21st Century*. UK: Institute of Development Studies, 1992.

Chowdhury, K. M. M. H. "Cyclone Preparedness and Management in Bangladesh." In: BPATC (ed) *Improvement of Early Warning System and Responses in Bangladesh Towards Total Disaster Risk Management Approach.* Dhaka: BPATC, 2000.

Chowdhury, Shamsuddoha, and Rezaul Karim. *Climate Change Impact and Disaster Vulnerabilities in the Coastal Areas of Bangladesh*. COAST Trust: 2007.

James, William Philip Trehearne, and E. Claire Schofield. *Human Energy Requirements. A Manual for Planners and Nutritionists*. Oxford: Oxford University Press, 1990.

Kothari, Chakravanti Rajagopalachari. *Research Methodology: Methods and Techniques*. New Delhi: New Age International, 2004.

Nasreen, Mahbuba. *Impact of Climate Change on Agriculture and Food Security*. Bangladesh: Action Aid International and Action Aid, 2008.

Osvaldo F Jean P. Canziani, Palutikof, Paul J. van der Linden, and Clair E. Hanson, *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Edited by Martin Parry. Vol.4. Cambridge: Cambridge University Press, 2007.

Lemke, Peter, Jiawen Ren, Richard B. Alley, Ian Allison, Jorge Carrasco, Gregory Flato, and Yoshiyuki Fujii. "Observations: Changes in Snow, Ice and Frozen Ground," in S. Solomon et al., eds., *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press, 2007.

PDO-CZMP. *Where Land Meets the Sea: A Profile of the Coastal Zone of Bangladesh.* Dhaka: The University Press Limited, 2004.

Pelling, M. *The Vulnerability of Cities*. London: Earthscan Publication Ltd., 2003.

Rahman, A. *Beel Dakatia: The Environmental Consequences of a Development Disaster*. Dhaka: University Press, 1995.

Sen, A.K. *Poverty and Famines: An Essay on Entitlement and Deprivation*. Oxford: Oxford University Press, 1981.

Twigg, John. *Corporate Social Responsibility and Disaster Reduction: A Global Overview*. London: Benfield Greig Hazard Research Centre, 2001.

Warrick, R.A. and Q.K. Ahmad (Eds.). *The Implications of Climate and Sea-Level Change for Bangladesh,* London: Kluwer Academic Publishers, 1996.

Articles in Print

Adger, W. Neil, Saleemul Huq, Katrina Brown, Declan Conway, and Mike Hulme. "Adaptation to Climate Change in the Developing World." *Progress in Development Studies* 3, no. 3 (2003): 179-195.

Adger, W. Neil. "Social Vulnerability to Climate Change and Extremes in Coastal Vietnam." *World development* 27, no. 2 (1999): 249-269.

Agarwal, B. “Social Security and the Family: Coping with Seasonality and Calamity in Rural India.” *Journal of Peasant Studies* 17, no.3 (1990): 341-342.

Agrawala, Shardul, Tomoko Ota, Ahsan Uddin Ahmed, Joel Smith, and Maarten Van Aalst. "Development and Climate Change in Bangladesh: Focus on Coastal Flooding and the Sundarbans." *OECOD, France* no.3 (2003): 1-70.

Ahmad, Mohiuddin, and A. Atiq Rahman. "The Stimulating Role of Ngos in Bangladesh." *Climate of Coastal Cooperation. Coastal & Marine Union, the Netherlands* (2011): 62-63.

Ahmad, Q. K., and Ahsan Uddin Ahmed. "Regional Cooperation in Flood Management in the Ganges-Brahmaputra-Meghna Region: Bangladesh Perspective." In *Flood Problem and Management in South Asia*, Springer Netherlands, (2003): 181-198.

Ahmed, A. U. “Toward Integrating Adaptation to Climate Change in Current Policy Regime: Perspectives on Bangladesh’s Water Resources and Associated Sectors.” *Asia Pacific Journal on Environment and Development* 12(2005): 35-54.

Ahmed, Ahsan Uddin, Mozaharul Alam, and A. Atiq Rahman. "Adaptation to Climate Change in Bangladesh: Future Outlook." In *Vulnerability and Adaptation to Climate Change for Bangladesh*, Springer Netherlands (1999): 125-143.

Ahmed, Nesar, Harvey Demaine, and James F. Muir. "Freshwater Prawn Farming in Bangladesh: History, Present Status and Future Prospects." *Aquaculture Research* 39, no. 8 (2008): 806-819.

Alaimo, Katherine, Ronette R. Briefel, Edward A. Frongillo Jr, and Christine M. Olson. "Food Insufficiency Exists in the United States: Results From the third National Health and Nutrition Examination Survey (NHANES III)." *American Journal of Public Health* 88, no. 3 (1998): 419-426.

Alam, M. Shamsul, and Kabir Uddin. "A Study of Morphological Changes in the Coastal Areas and Offshore Islands of Bangladesh Using Remote Sensing." *American Journal of Geographic Information System* 2, no. 1 (2013): 15-18.

Alam, Md Ferdous and Kenneth J. Thomson. "Current Constraints and Future Possibilities for Bangladesh Fisheries." *Food Policy* 26, no. 3 (2001): 297-313.

Ali, Abu Muhammad Shajaat. "Rice to shrimp: Land use/land cover changes and soil degradation in Southwestern Bangladesh." *Land Use Policy* 23, no. 4 (2006): 421-435.

Ali, Anwar. "Climate Change Impacts and Adaptation Assessment in Bangladesh." *Climate Research* 12, no. 2-3 (1999): 109-116

Allison, Edward H., and Frank Ellis. "The Livelihoods Approach and Management of Small-Scale Fisheries." *Marine Policy* 25, no. 5 (2001): 377-388.

Anne, Swindal, and Paula Bilinsky. "Development of a Universally Applicable Household Food Insecurity Measurement Tool: Process, Current Status, and Outstanding Issues." *The Journal of Nutrition* 136, no. 5 (2006): 1449S-1452S.

Ayers, Jessica M., and Saleemul Huq. "The Value of Linking Mitigation and Adaptation: A Case Study of Bangladesh." *Environmental Management* 43, no. 5 (2009): 753-764.

Barnett, Jon. "Security and Climate Change." *Global Environmental Change* 13, no. 1 (2003): 7-17.

Baron, Angela. "Measuring Human Capital." *Strategic HR Review* 10, no. 2 (2011): 30-35.

Barro, Robert J., and Jong-Wha Lee. "IMF Programs: Who is Chosen and what are the Effects?" *Journal of Monetary Economics* 52, no. 7 (2005): 1245-1269.

Bebbington, Anthony. "Capitals and Capabilities: A Framework for Analyzing Peasant Viability, Rural Livelihoods and Poverty." *World Development* 27, no. 12 (1999): 2021-2044.

Behera, Bhagirath, and Stefanie Engel. "Institutional Analysis of Evolution of Joint Forest Management in India: A New Institutional Economics Approach." *Forest Policy and Economics* 8, no. 4 (2006): 350-362.

Belcher, John C. "A Cross-Cultural Household Level-Of-Living Scale." *Rural Sociology* 37, no. 2 (1972): 208-20.

Boateng, Isaac. "An Assessment of the Physical Impacts of Sea-Level Rise and Coastal Adaptation: A Case Study of the Eastern Coast Of Ghana." *Climatic Change* 114, no. 2 (2012): 273-293.

Borroto, R J. "Global Warming, Rising Sea Level, and Growing Risk of Cholera Incidence: A Review of the Literature and Evidence." *Geo Journal 44*, no.2 (1998):111-120.

Bosher, Lee, Edmund Penning-Rowsell, and Sue Tapsell. "Resource Accessibility and Vulnerability in Andhra Pradesh: Caste and Non-Caste Influences." *Development and Change* 38, no. 4 (2007): 615-640.

Broactus, J. M. "Possible Impacts of, and Adjustments to, Sea Level Rise: The Cases of Bangladesh and Egypt." *Climate and Sea Level Change: Observations, Projections, and Implications* 5 (1993): 263-70.

Cannon, Terry. "Vulnerability Analysis and the Explanation of Natural Disasters." *Disasters, Development and Environment* (1994): 13-30.

Carter, Michael R., Peter D. Little, Tewodaj Mogues, and Workneh Negatu. "Poverty Traps and Natural Disasters in Ethiopia and Honduras." *World Development* 35, no. 5 (2007): 835-856.

Cazenave, Anny, and R. Steven Nerem. "Redistributing Earth's Mass." *Science* 297, no. 5582 (2002): 783-784.

Cooper, Arnold C., F. Javier Gimeno-Gascon, and Carolyn Y. Woo. "Initial Human and Financial Capital as Predictors of New Venture Performance." *Journal of Business Venturing* 9, no. 5 (1994): 371-395.

Dalby, S. "Environmental Change and Human Security." *ISUMA*, (2000): 71-79.

Davies, Jonathan, and Richard Bennett. "Livelihood Adaptation to Risk: Constraints and Opportunities for Pastoral Development in Ethiopia's Afar Region." *The Journal of Development Studies* 43, no. 3 (2007): 490-511.

De Haen, Hartwig, and Günter Hemrich. "The Economics of Natural Disasters: Implications and Challenges for Food Security." *Agricultural Economics* 37, no. s1 (2007): 31-45.

Emery, Mary, and Cornelia Flora. "Spiraling-Up: Mapping Community Transformation with Community Capitals Framework." *Community Development* 37, no. 1 (2006): 19-35.

Ericson, J. P., C. J. Vörösmarty, S. L. Dingman, L. G. Ward, and M. Meybeck. "Effective Sea-Level Rise and Deltas: Causes of Change and Human Dimension Implications." *Global and Planetary Change50*, no.1 (2006), 63-82.

Ford, James D., and Barry Smit. "A Framework for Assessing the Vulnerability of Communities in the Canadian Arctic to Risks Associated with Climate Change." *Arctic 5,* no.4 (2004): 389-400.

Gaillard, Jean-Christophe, Emmanuel A. Maceda, Elodie Stasiak, Iwan Le Berre, and Maria Victoria O. Espaldon. "Sustainable Livelihoods and People's Vulnerability in the Face of Coastal Hazards." *Journal of Coastal Conservation* 13, no. 2-3 (2009): 119.

Griggs, David J., and Maria Noguer. "Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change." *Weather* 57, no. 8 (2002): 267-269.

Grothmann, Torsten, and Anthony Patt. "Adaptive Capacity and Human Cognition: The Process of Individual Adaptation to Climate Change." *Global Environmental Change* 15, no. 3 (2005): 199-213.

Haq, A. H. M. R., Tapan Kumar Ghosal, and Pritam Ghosh. "Cultivating Wetlands in Bangladesh." *Leisa Magazine* 20, no. 4 (2004): 18-20.

Haque, C. Emdad, and Muhammad Qasim Zaman. "Human Responses to Riverine Hazards in Bangladesh: A Proposal for Sustainable Floodplain Development." *World Development* 21, no. 1 (1993): 93-107.

Haque, C. Emdad. "Climatic Hazards Warning Process in Bangladesh: Experience of, and Lessons From, The 1991 April Cyclone." *Environmental Management* 19, no. 5 (1995): 719-734.

Haque, C. E. and D. Blair. “Vulnerability to Tropical Cyclones: Evidence from the April 1991 Cyclone in Coastal Bangladesh.” *Disasters* 16, no.3 (1992): 217–229.

Hinkel, Jochen, and Richard JT Klein. "Integrating Knowledge to Assess Coastal Vulnerability to Sea-Level Rise: The Development of the DIVA Tool." *Global Environmental Change* 19, no. 3 (2009): 384-395.

Hossain, Md Shahadat. "Biological Aspects of the Coastal and Marine Environment of Bangladesh." *Ocean & Coastal Management* 44, no. 3 (2001): 261-282.

Huq, Saleem-ul, Ahsan U. Ahmed, and Rob Koudstaal. "Vulnerability of Bangladesh to Climate Change and Sea Level Rise." In *Climate Change and World Food Security*, Springer Berlin Heidelberg, (1996): 347-379.

Huq, Saleemul, Hannah Reid, Mama Konate, A. Atiq Rahman, Youba Sokona, and Florence Crick. "Mainstreaming Adaptation to Climate Change in Least Developed Countries (Ldcs)." *Climate Policy* 4, no. 1 (2004): 25-43.

Huq, Saleemul. "Climate Change and Bangladesh." *Science* 294, no. 5547 (2001): 1617-1617.

Hutton David and C. Emdad Haque. "Patterns of Coping and Adaptation Among Erosion-Induced Displaces in Bangladesh: Implications for Hazard Analysis and Mitigation." *Natural Hazards* 29, no. 3 (2003): 405-421.

Iftekhar, M. S., and M. R. Islam. "Managing Mangroves in Bangladesh: A Strategy Analysis." *Journal of Coastal Conservation* 10, no. 1 (2004): 139-146.

Islam, M. S. "Perspectives of the Coastal and Marine Fisheries of the Bay of Bengal, Bangladesh.” *Ocean & Coastal Management* 46, no. 8 (2003): 763-796.

Islam, M. S. "Perspectives of the Coastal and Marine Fisheries of the Bay Of Bengal, Bangladesh.” *Ocean & Coastal Management 46,* no. 8 (2003): 763-796.

J.G. Titus, R.A. Park, Leatherman, S.P.Weggel S.P. J.R. Greene, M.S. Mausel, P.W., Brown, S. Gaunt, and G. Trehan. “Greenhouse Effect and Sea Level Rise: The Cost of Holding Back the Sea.” *Coastal Management* 19(1991): 171-204.

John D. Milliman, James M. Broadus, and Frank Gable "Environmental and Economic Implications of Rising Sea Level and Subsiding Deltas: The Nile and Bengal Examples," *Ambio* (1989): 345.

Jonathan Davies, and Richard Bennett. "Livelihood Adaptation to Risk: Constraints and Opportunities for Pastoral Development in Ethiopia's Afar Region." *The Journal of Development Studies* 43, no. 3 (2007): 490-511.

Karim, MD Masud. "Arsenic in Groundwater and Health Problems in Bangladesh." *Water Research* 34, no. 1 (2000): 304-310.

Karim, Mohammed Fazlul, and Nobuo Mimura. "Impacts of climate change and sea-level rise on cyclonic storm surge floods in Bangladesh." *Global Environmental Change* 18, no. 3 (2008): 490-500.

Karim. Z, S. G. Hussain, and M. Ahmed. “Assessing Impacts of Climate Variationson Food grain Production in Bangladesh.” *Water, Air, and Soil Pollution* 92(1996): 53-62.

Khan, Md Modasser Hossain, Ian Bryceson, Korine N. Kolivras, Fazlay Faruque, M. Mokhlesur Rahman, and Ubydul Haque. "Natural Disasters and Land-Use/Land-Cover Change in the Southwest Coastal Areas of Bangladesh." *Regional Environmental Change* 15, no. 2 (2015): 241-250.

Khan, Mizan R., and M. Ashiqur Rahman. "Partnership Approach to Disaster Management in Bangladesh: A Critical Policy Assessment." *Natural Hazards* 41, No. 2 (2007): 359-378.

Khan, Yusuf Sharif Ahmed, and M. Sahadat Hossain. "Impact of Shrimp Culture on the Coastal Environment of Bangladesh." *International Journal of Ecology and Environmental Sciences* 22, no. 2 (1996): 145-158.

Klein, R.T., and Nicholls, R.J. “Assessment of Coastal Vulnerability to Climate Change.” *Ambio*28, no.2 (1999): 182–187.

Lindenberg, Marc. "Measuring Household Livelihood Security at the Family and Community Level in the Developing World." *World Development* 30, no. 2 (2002): 301-318.

M Alam, Shamsul, and Kabir Uddin. "A Study of Morphological Changes in the Coastal Areas and Offshore Islands of Bangladesh Using Remote Sensing." *American Journal of Geographic Information System* 2, no. 1 (2013): 15-18.

Mahmud, Tanvir, and Martin Prowse. "Corruption in Cyclone Preparedness and Relief Efforts in Coastal Bangladesh: Lessons for Climate Adaptation?" *Global Environmental Change* 22, no. 4 (2012): 933-943.

Mallick, Bishaw Jit, Sebastian Marcel Witte, Raju Sarkar, Apurba Swatee Mahboob, and Joachim Vogt. "Local Adaptation Strategies of a Coastal Community during

Cyclone Sidr and Their Vulnerability Analysis for Sustainable Disaster Mitigation Planning in Bangladesh." *Journal of Bangladesh Institute of Planners* 2 (2009): 158-168.

Maxwell, Daniel G. "Measuring Food Insecurity: The Frequency and Severity of "Coping Strategies"." *Food policy* 21, no. 3 (1996): 291-303.

McLean, R. F., A. Tsyban, V. Burkett, J. O. Codignotto, D. L. Forbes, and V Ittekkot. "Coastal Zones and Marine Ecosystems." *Climate Change*, (2001): 343-379.

Mei-E, Ren. "Relative Sea Level Rise in China and Its Socioeconomic Implications." *Marine Geodesy* 17, no. 1 (1994): 37-44.

Milliman, John D., James M. Broadus, and Frank Gable. "Environmental and Economic Implications of Rising Sea Level and Subsiding Deltas: The Nile and Bengal Examples." *Ambio* (1989): 340-345.

Minar, M. H., M. Belal Hossain and M. D. Shamsuddin. "Climate Change and Coastal Zone Of Bangladesh: Vulnerability, Resilience and Adaptability." *Middle-East Journal of Scientific Research* 13, no. 1 (2013): 114-120.

Morris, Saul S., Oscar Neidecker-Gonzales, Calogero Carletto, Marcial Munguía, Juan Manuel Medina, and Quentin Wodon. "Hurricane Mitch and the Livelihoods of the Rural Poor in Honduras." *World Development* 30, no. 1 (2002): 49-60.

Mustafa, D. "Reinforcing Vulnerability? Disaster Relief, Recovery, and Response to the 2001 Flood in Rawalpindi, Pakistan." *Environmental Hazards* 5(2003): 71–82.

Nerem, R. S., D. P. Chambers, E. W. Leuliette, G. T. Mitchum, and B. S. Giese. "Variations in Global Mean Sea Level Associated with the 1997–1998 ENSO Event: Implications for Measuring Long Term Sea Level Change." *Geophysical Research Letters* 26, no. 19 (1999): 3005-3008.

Nicholls, Robert J., and Anny Cazenave. "Sea-Level Rise and Its Impact on Coastal Zones." *Science* 328, no. 5985 (2010): 1517-1520.

Nicholls, Robert J., and Nobuo Mimura. "Regional Issues Raised By Sea-Level Rise and Their Policy Implications." *Climate Research* 11, no. 1 (1998): 5-18.

Nicholls, Robert J., Poh Poh Wong, Virginia Burkett, Colin D. Woodroffe, and John Hay. "Climate Change and Coastal Vulnerability Assessment: Scenarios for Integrated Assessment." *Sustainability Science* 3, no. 1 (2008): 89-102

Nishat, Ainun, and Islam M. Faisal. "An Assessment of the Institutional Mechanisms for Water Negotiations in the Ganges-Brahmaputra-Meghna System." *International Negotiation* 5, no. 2 (2000): 289-310.

Oerlemans, J. "Effect of Irregular Fluctuations in Antarctic Precipitation on Global Sea Level." *Nature* 290 (1981): 770-772.

Pall, P., M. R. Allen, and D. A. Stone. "Testing the Clausius–Clapeyron Constraint on Changes in Extreme Precipitation under CO2 Warming." *Climate Dynamics* 28, no. 4 (2007): 351-363.

Paul, S. K., and J. K. Routray. “Flood Proneness and Coping Strategies: The Experiences of Two Villages in Bangladesh.” *Disasters* 34. No.2 (2010): 489-508.

Paul, Shitangsu Kumar. "Prevalence of Nutritional Insecurity in the Central Coast of Bangladesh: Evidences from Cyclone Sidr’." *The Journal of Geo-Environment* 10 (2010): 22-35.

Peltier, W. R. “Postglacial Variations in the Level of the Sea: Implications for Climate Dynamics and Solid-Earth Geophysics.” *Rev. Geophysics* 36, no.4 (1998): 603–689.

R. F. McLean, A. Tsyban, V. Burkett J. O. Codignotto, D. L. Forbes, N., and V Ittekkot. “Coastal Zones and Marine Ecosystems.” *Climate Change*, (2001): 343-379.

R.A., Warrick and J. Oerlemans, Sea Level Rise. In: *Climate Change, the IPCC Scientific Assessment.* J.T. Houghton, G.J. Jenkins, J.J. Ephraums (eds.) (1990): 260-281.

Rakodi, Carole. "A Capital Assets Framework for Analyzing Household Livelihood Strategies: Implications for Policy." *Development Policy Review* 17, no. 3 (1999): 315-342.

Rashid, M. M., A. K. F. Hoque, and M. S. Iftekhar. "Salt Tolerances of Some Multipurpose Tree Species As Determined By Seed Germination." *Journal of Biological Sciences* 4, no. 3 (2004): 288-292.

Ronnenberg, Alayne G., Xiaobin Wang, Houxun Xing, Chanzhong Chen, Dafang Chen, Wenwei Guang, Aiqun Guang, Lihua Wang, Louise Ryan, and Xiping Xu. "Low Preconception Body Mass Index is Associated with Birth Outcome in a Prospective Cohort of Chinese Women." *The Journal of Nutrition* 133, no. 11 (2003): 3449-3455.

Russell, Grahame. "Hurricane Mitch and Human Rights." *Development in Practice* 9, no. 3 (1999): 322-325.

Sanderson, David. "Cities, Disasters and Livelihoods." *Environment and Urbanization* 12, no. 2 (2000): 93-102.

Saroar, Md Mustafa, Jayant K. Routray, and Walter Leal Filho. "Livelihood Vulnerability and Displacement in Coastal Bangladesh: Understanding the Nexus." In *Climate Change in the Asia-Pacific Region*, Springer International Publishing, (2015): 9-31.

Sarwar, G. M. and M. H. Khan. “Sea Level Rise: A Threat to the Coast of Bangladesh.” *Internationales Asien Forum38*, No. 3–4, (2007): 375–397.

Schipper, Lisa, and Mark Pelling. "Disaster Risk, Climate Change and International Development: Scope for, and Challenges to, Integration." *Disasters* 30, no. 1 (2006): 19-38.

Sen, Amartya. "Famines." *World Development* 8, no. 9 (1980): 613-621.

Shah Alam Khan, M. "Disaster Preparedness for Sustainable Development in Bangladesh." *Disaster Prevention and Management: An International Journal* 17, no. 5 (2008): 662-671.

Smil, Vaclav. "How Many People Can the Earth Feed?" *Population and Development Review* (1994): 255-292.

Smit, Barry, and Mark W. Skinner. "Adaptation Options in Agriculture to Climate Change: A Typology." *Mitigation and Adaptation Strategies for Global Change* 7, no. 1 (2002): 85-114.

Smith, Ben J., Kwok Cho Tang, and Don Nutbeam. "WHO Health Promotion Glossary: New Terms." *Health Promotion International* 21, no. 4 (2006): 340-345.

Sorensen, John H. "Hazard Warning Systems: Review of 20 Years of Progress." *Natural Hazards Review* 1, no. 2 (2000): 119-125.

Steel, B., N. Lovrich, D. Lach, and V. Fomenko. “Correlates and Consequences of Public Knowledge Concerning Ocean Fisheries Management.” *Coastal Management* 33(2005): 37-51.

Turner, R. Kerry, Susan Subak, and W. Neil Adger. "Pressures, Trends, and Impacts in Coastal Zones: Interactions between Socioeconomic and Natural Systems." *Environmental Management* 20, no. 2 (1996): 159-173.

Uggla, Ylva. "What is This Thing Called 'Natural'? The Nature-Culture Divide in Climate Change and Biodiversity Policy." *Journal of Political Ecology* 17 (2010): 79-91.

Walingo, Mary Khakoni. "The Role of Education in Agricultural Projects for Food Security and Poverty Reduction in Kenya." *International Review of Education* 52, no. 3-4 (2006): 287-304.

Warrick, R. A., G. J. Kenny, G. C. Sims, N. J. Ericksen, Q. K. Ahmad, and M. Q. Mirza. "Integrated Model Systems for National Assessments of the Effects of Climate Change: Applications in New Zealand and Bangladesh." In *Climate Change Vulnerability and Adaptation in Asia and the Pacific* (Springer, Netherlands) (1996): 215-227.

Warrick, R.A., and J. Oerlemans. Sea Level Rise. In: *Climate Change, the IPCC Scientific Assessment.* J.T. Houghton, G.J. Jenkins, J.J. Ephraums (eds.) (1990): 260-281.

Wigley, T.M.L. and S.C.B. Raper. “Interpretation of High Projections for Global Mean Warming.” *Science* 293, (2001): 451–54.

Wigley, Tom ML, and S. C. B. Raper. "Thermal Expansion of Sea Water Associated with Global Warming." *Nature* 330, no. 6144 (1987): 127-131.

World Bank. *Bangladesh: Climate Change and Sustainable Development*. *Report No. 21104-BD*, Rural Development Unit, South Asia Region, The World Bank, Dhaka, (2000):95.

Articles Online

Adger W. Neil, Shardul Agrawala, M. Monirul Qader Mirza, Cecilia Conde, Karen O’Brien, Juan Pulhin, Roger Pulwarty, Barry Smit, and Kiyoshi Takahashi. "Assessment of Adaptation Practices, Options, Constraints and Capacity." *Climate*

Change (2007): 717-743. Available at http://www.resalliance.org/publications/694 (accessed on 19 March 2016).

Chambers, R. and Conway, R. Sustainable Rural Livelihood: Practical Concepts for 21th Century, Institute Of Development Studies and Poverty Research Unit, University Of Sussex, *IDS Discussion Paper* 296(1992). Available at https:/ /www.staff.ncl. ac.uk/ david. Harvey /AEF806/Sconnes1998.pdf (accessed on 15 March 2016).

DFID. "*Sustainable Livelihoods Guidance Sheets, the Livelihoods Framework*." Department for International Development, UK. *Section* 2(1999) available at www.eldis.org/vfile/muspload/1/ document/0901/section2.pdf (accessed on 13 March 2016).

DFID. *Partnership with the Private Sector*, Department for International Development, 2000. Available at www.dfid.gov.uk/public/working/buspart (accessed on 30 April 2016).

Earth policy Institute. "Increased Flows of Environmental Refugees." Available at http: //www.edcnews.se/cases/EnvRefugeesBrown.html (accessed on 14 October 2016).

FAO. *Bangladesh: Country Overview,* retrieved from http:// www.fao.org/ag/agl/ swlwpnr/ reports/y_sa/z_bd/ bd.htm #overview (2004) accessed 21 July 2016.

FAO. *Special Report FAO/WFP Crop and Food Supply Assessment Mission to Bangladesh,* available at http://www.fao.org/docrep/011/ai472e/ai472e00 (2008).html (accessed on 11 June 2016).

Frankenberger, T. "Measuring Household Livelihood Security: An Approach for Reducing Absolute Poverty." Paper Prepared for the *Applied Anthropology Meetings*, Baltimore, March (1996) available at http://www.fao.org/3/a-x0051t/ X0051t05.htm (accessed on 18 June 2016).

Haque, Md Zahurul, and Md Saifuzzaman. "Social and Environmental Effects of Shrimp Cultivation in Bangladesh: Notes on Study Methods." *Globalization, Environmental Crisis and Social Change in Bangladesh, Dhaka, Bangladesh*, UPL. (2003): 1-19. Available at https://www.researchgate.net/publication/ 265080498 (accessed on 15 April 2016).

Haraldsson, H V. *Introduction to System Thinking and Causal Loop Diagrams*. Department of Chemical Engineering, Lund University, Lund (2004). Available at https://www.researchgate.net/publication/313405754 accessed 17 January 2017.

Rahman, M R. "Impact of Riverbank Erosion Hazard in the Jamuna Floodplain Areas in Bangladesh." *J. Sci. Foundation* 8, no. 1&2(2010): 55-65. Available at *www.banglajol. info/index.php/JSF/article/ download/14627/10382* accessed 23 October 2016.

Sarwar, Md Golam Mahabub. "Impacts of Sea Level Rise on the Coastal Zone of Bangladesh." available at *http://static. weadapt. Org/placemarks/files/225 /golam_sarwar. pdf* (2005). (accessed 15 June 2016).

UNICEF. “Child and Maternal Nutrition in Bangladesh (Undated).” available at http://www.unicef.org/bangladesh/Child_and_Maternal_Nutrition.pdf (accessed on 3 November 2016).

World Bank, “Water in South Asia” (2010), available at http://web.worldbank.org/ wbsite/ external/countries/southasiaext/0, content mdk: 21652275~ pagepk: 146736~pipk: 146830~ thesitepk: 223547, 00.html (accessed March 3, 2016).

World Bank. "Bangladesh: Climate Change & Sustainable Development. Dhaka, World Bank Office." *South Asia Rural Development Team* (2000). Available at http://documents. worldbank.org/curated/en/906951468743377163/Bangladesh-Climate-change-and-sustainable-development (Accessed on 15 March 2016).

World Bank. “Climate Change.” Available at *http://wb_gfdrr_climate_change_country_ profile_for_ BGD.pdf*, 1998 (accessed on 17 July 2016).

www.cires1.colorado.edu/science/groups/pielke/pubs/books/ bookchapters.html (accessed on 30 June 2016).

Dissertations

Deb, Apurba Krishna. “Voices of the Fishantry: Learning on the Livelihood Dynamics from Bangladesh.” PhD diss., University of Manitoba, Winnipeg, Manitoba, Canada, 2009.

Haque, A. J. M. Mainul. “Impacts of Shrimp Culture on Socio-economic Conditions in the Coastal Region of South-West Bangladesh.” PhD diss., Institute of Environmental Science, University of Rajshahi, 2002.

Islam, Md. Rabiul. “Building Disaster Resilient Coastal Community in a Multi-hazards of Bangladesh.” M Sc. Thesis., Asian Institute of Technology, Thailand, 2010.

Khalil, Md Ibrahim. “Coping Strategies of the Cyclone-Affected Farmers in Coastal Areas of Bangladesh.” PhD diss., Institute of Bangladesh Studies, University of Rajshahi, 2012.

Minhaz, A. “Coping with disasters in Bangladesh: people’s vulnerability and survival strategy.” PhD diss., Institute of Bangladesh Studies, University of Rajshahi, 2013.

Shoeb, A. Z. M. “Flood in Bangladesh: Disaster Management and Reduction of Vulnerability: A Geographical Approach.” PhD diss., Institute of Bangladesh Studies, University of Rajshahi, 2002.

Reports

Bangladesh Bureau of Statistics, *Reports of the Household Income and Expenditure Survey 2010*. Bangladesh Bureau of Statistics, Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh (Dhaka: December 2011).

Bangladesh Bureau of Statistics. *Statistical Yearbook of Bangladesh 2011*. 31st ed. Bangladesh Bureau of Statistics, Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh (Dhaka: September 2012).

Black, Kerry and Shaw Mead. "Wave Rotation for Coastal Protection." In *Coasts & Ports 2001: Proceedings of the 15th Australasian Coastal and Ocean Engineering Conference, the 8th Australasian Port and Harbor Conference*. Institution of Engineers, Australia, 2001:120.

Chambers, Roberts. *Sustainable Livelihoods, Environment and Development: Putting Poor Rural People First,* Institute of Development Studies and Poverty Research Unit. IDS Discussion Paper 20(1988).

DFID. *Partnership with the private sector*, Department for International Development (2000), available at www.dfid.gov.uk/public/working/buspart/ accessed April 30, 2016.

Drinkwater, M., and M. McEwan. *Household Food Security and Environmental Sustainability in Farming Systems Research: Developing Sustainable Livelihoods*. A Paper Presented to the Adaptive Research Planning Team (1992).

Houghton, John T., D. L. Albritton, L. G. Meira Filho, U. Cubasch, X. Dai, Y. Ding, D. J. Griggs et al. *Technical Summary Of Working Group* 1. Cambridge University Press, 2001.

IPCC. *Climate Change 2001: Synthesis Report*. Contribution of Working Group III to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), Cambridge University Press, UK, 2001b.

IPCC**.** *Climate Change 2001: Impacts, Adaptation and Vulnerability*. Cambridge: Cambridge University Press, 2001b.

IPCC. *Climate Change 2001: The Scientific Basis*. Contribution of Working Group I to The Third Assessment Report of the IPCC. Cambridge: Cambridge University Press, 2001a.

IPCC. Climate change 2007: *Synthesis Report*. Intergovernmental panel on climate change, 2007. Available at: http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf (accessed 12 February 2016).

IPCC. *Technical Summary*, A Report of Working Group 1 of the Intergovernmental Panel on Climate Change, 2007.

McLeod, Ruth. *The Impact of Regulations and Procedures on the Livelihoods and Asset Base of the Urban Poor–A Financial Perspective*. Working paper, Homeless International, Coventry, 2001.

Nasreen, Mahbuba, K. M. Hossain, and M. A. K. Azad. *Climate Change and Livelihood in Bangladesh: Experiences of People Living In Coastal Regions*. Proce. of Int. Con. of Building Resilience (2013): 1-25.

National Institute of Population Research and Training. *Bangladesh Demographic and Health Survey 2011*. Mitra and Associates, Dhaka, Bangladesh (Dhaka: April 2012), 32.

Rahman, A. Atiq et al. *Risks, Vulnerability and Adaptation in Bangladesh, Human Development Report*2007/2008, Occasional Paper 2007/13 (New York: United Nations Development Programme, 2007).

Warrick, R. A., A. H. Bhuiya, and M. Q. Mirza. *Climate Change and Sea-level Rise: the Case of the Coast*. Briefing Document 6 (1993).

World Bank. *Bangladesh: Climate Change and Sustainable Development* (2000). Report No. 21104-BD, Rural Development Unit, South Asia Region, The World Bank (WB), Dhaka, pp. 95.

Websites

www.cegisbd.com/projects.aspx

www.icccad.net/wp-content/uploads/2015/01/IPCC-Briefing-for-Bangladesh.pdf

www.ipcc.ch/ publications_and_data/ar4/wg1/en/ch4s4-4.html

www.slideshare.net/sea-level-rise-emerging-issues-paper-royal-society-of-new-zeal

www.static. weadapt.org/placemarks/files/225/golam_sarwar. pdf

WWW.wb_gfdrr_climate_change_country_profile_for_BGD.pdf

www.worldbank.org/2013/warming-climate-to-hit-bangladesh-hard-with-sea-lev

www.worldbank.org/en/news/press-release/2013/06/19/warming-climate-to-hit-bangladesh-hard-with-sea-level-rise-more-floods-and-cyclones-world-bank-report-says