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Mustafa Alam *Editors*

Living on the Edge

Char Dwellers in Bangladesh

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Char Dwellers in Bangladesh

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Char at a distance within a river (*source* www.dhakatribune.com)

This book is dedicated to the teeming millions of riverine and coastal char dwellers in Bangladesh, who impress us with their resilience in 'living on the edge'; to whom we owe an obligation of ensuring a life better than what they currently eke out.

Preface

The idea of this book triggered following a series of op-eds by Mohammad Zaman in the *Financial Express*, Dhaka (March–June 2019) on the plight of communities living in chars within the rivers of Bangladesh. Mustafa Alam, who earlier conducted extensive studies on chars under the aegis of the Flood Action Plan, followed up on the op-eds, suggesting we could together edit a book on the subject of chars in Bangladesh. We were both enthused by the idea and sent out a Call for Papers in June 2019, which received encouraging responses from many of our erstwhile colleagues and other professionals around the globe.

It is gratifying to note that our initiative has brought together a multidisciplinary and global team of international and national experts, contributing chapters to the book on the diverse physical, environmental, socio-economic and institutional issues concerning chars in Bangladesh. We hope all this will prove valuable to academicians, policy planers and development practitioners alike.

Looking back, compiling this volume was not an easy task. As editors, it was a challenge going through multiple levels of professional interaction with all so many authors, providing feedback on their drafts and pulling the net together at the end. This truly collaborative task was possible only because we received full and continuous support from all concerned in the entire process.

We like to thank Jakia Akter and her Team at the Centre for Environmental and Geographic Information Services (CEGIS) in Dhaka for producing a number of maps used in the introductory part of the book. We also want to thank Dr. Robert Doe, Editor of the Springer Series in Geography/Human-Environment Research, and the Springer Production Team Lead Rajan Muthu and Ritu Chandwani for their understanding support.

Sadly, Hugh Brammer (1925–2021), one important contributor to the volume, died of COVID-19 in January 2021. A geographer and a soil scientist of repute, he had a deep love for Bangladesh, which he considered his second home. He was advisor to the Food and Agriculture Organization (FAO)—Bangladesh. He will be remembered for his wisdom as well as his warmth and generosity.

Our objective, and indeed, the driving force behind the book, has been to bring the isolated chars and char people into the forefront of development discourse in the country. We will consider our sincere effort in producing this volume a success only when this objective is met.

Finally, our families and friends shouldered additional burdens in more ways than one during the stretch of time over which we prepared the manuscript of the book. We thank them all.

Vancouver, B.C., Canada Mohammad Zaman
Vancouver, B.C., Canada Mustafa Alam

About This Book

Panoramic view of charland in the dry season (*source The Daily Star*, Dhaka)

In Bangladesh, the chars within the river channels are an important part of its landscape. However, these land masses continue to remain isolated, deprived of services, and pockets of poverty in the country. The char dwellers are vulnerable to natural hazards like flood and erosion. In addition to these hazards, the coastal chars are faced with the imminent problem of widespread inundation due to sea level rise resulting from climate change.

Within this context, the book *Living on the Edge: Char Dwellers in Bangladesh* has brought together valuable scholarship on the diverse issues relating to the chars and the communities living in there. This comprehensive collection, with contribution of experts on the subject from across the globe, provides an understanding of the problems faced by the char dwellers and also comes up with policy prescriptions for ensuring overall welfare of char communities in the country.

Contents

Editors and Contributors

About the Editors

Mohammad Zaman is an international development/resettlement specialist and advisory professor, National Research Center for Resettlement, Hohai University, Nanjing, China. He carried out extensive ethnographic research on disaster and displacement in the Brahmaputra-Jamuna floodplain. For many years, his core research has been on char settlement, their economies and social organizations and how these have been historically shaped by the colonial and post-colonial land tenure and administration with regard to alluvial and diluvial lands. He is a Fellow of the Society for Applied Anthropology, and advisor to the Administrative Staff College of India, Hyderabad, India.

Mustafa Alam, a Professor (Retired) in Economics, University of Dhaka, Bangladesh, has a rich background in research on issues relating to integrated water resources management. He participated as a professional team member in several Flood Action Plan study components in Bangladesh, where his involvement in the multidisciplinary Charland Study figured prominently. Prof. Alam gained valuable experience about char life in the country through this study, whereby he carried out extensive fieldwork in numerous chars spread around all the major river systems of the country. Apart from miscellaneous reports he produced on issues relating to chars in Bangladesh, he has a number of valuable publications to his credit on the subject. Given this background, Prof. Alam's role as an editor of this volume certainly adds value to the discourses therein.

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Abbreviations

A2F	Access to Finance
AC	Assistant Commissioner (Land)
ADC	Additional Deputy Commissioner
AED	Alternate Wetting and Drying
AGEP	Agricultural Growth and Employment Program
ASA	Association for Social Advancement
ASPS	Agricultural Sector Programme Support
ATP	Asset Transfer Programme
AUSAID	Australian Aid for International Development
BAC	Bank attached chars or forced bar
BADA	Bengal Alluvion and Diluvion Regulation Act of 1825
BBS	Bangladesh Bureau of Statistics
BBS HHIES	Bangladesh Bureau of Statistics, Household Income and Expenditure Survey
BCR	Benefit-cost ratio
BDP 2100	Bangladesh Delta Plan 2100
BFRI	Bangladesh Fisheries Research Institute
BI	Braided Index
BRAC	Bangladesh Rural Advancement Committee
BRCS	Bangladesh Red Crescent Society
BUET	Bangladesh University of Engineering and Technology
BWDB	Bangladesh Water Development Board
CARE	Cooperative for Assistance and Relief Everywhere
CARE-BD	CARE-Bangladesh
CBCs	Char Business Centres
CBOs	Community Based Organization
CCM	Cyclone Classifier Model
CDA	Char Development Authority
CDSP	Char Development and Settlement Project
CEGIS	Center for Environmental and Geographic Information Services
CFPR	Challenging the Frontiers of Poverty Reduction

CFPR-TUP	Challenging the Frontiers of Poverty Reduction Targeting the Ultra Poor
CIDs	Char Input Dealers
CIRM	Centre for Insurance and Risk Management
CLP	Chars Livelihoods Programme
CPHHs	Core Participant Households
CPK	Char Pushti Karmi (Char Nutrition Worker)
CPP	Cyclone Preparedness Programme
CSK	Char Shasthya Karmi (Char Health Worker)
CSO	Civil Society Organization
DAE	Department of Agriculture Extension
DANIDA	Danish International Development Assistance
DC	Deputy Commissioner
DEM	Digital Elevation Model
DFAT	Department of Foreign Affairs and Trade (of Australia)
DFID	Department for International Development
DFID-B	Department for International Development-Bangladesh
DG-LRS	Director-General, Land Record Survey
DLS	Department Livestock Services
DMB	Disaster Management Bureau
DMC	Downstream mid-channel chars
DOF	Department of Fisheries
DPHE	Department of Public Health Engineering
DRR	Disaster Risk Reduction
DRTD	Declaration on the Right to Development
EBSATA	East Bengal State Acquisition and Tenancy Act (1950)
EDP	Estuary Development Project
EEP	Economic Empowerment of the Poor
FAO	Food and Agriculture Organization
FAP	Flood Action Plan
FFS	Farmer Field School
FFWC	Flood Forecasting and Warning Centre
FGDs	Focus Group Discussions
FGMs	Focus group meetings
FYP	Five-Year Plan
GBM	Ganges-Brahmaputra-Meghna
GDP	Gross Domestic Products
GED	General Economic Division
GIS	Geographical Information System
GNAEP	Greater Noakhali Aquaculture Extension Project
GoB	Government of Bangladesh
GUK	Gono Unnayan Kendra
GUP	Gono Unnayan Prochesta, Rajoir, Madaripur
GUP	Gram Unnayan Parishad
HH	Households

ICT	Information and Communications Technologies
IDPs	Internally displaced persons
IEP	Infrastructure Employment Project
IFAD	International Fund for Agricultural Development
IGA	Income-generating activities
IMD	Indian Meteorological Department
IMOs	Implementing Organizations
INCA	Integrated Catchment Model
INGOs	International Non-governmental Organizations
IPCC	Intergovernmental Panel on Climate Change
IPF	Integrated Prawn Farming
IRB	Institute of Review Board
ISISA	International Small Island Studies Association
IWFM	Institute of Water and Flood Management
IWMI	International Water Management Institute
IYCF	Infant and Young Child Feeding
KIIs	Key informant interviews
LFs	Local Facilitators
LGB	Lower Ganga Basin
LRP	Land Reclamation Project
LSP	Livestock Service Provider
M4C	Making Markets Work for the Jamuna, Padma and Teesta Chars
M4P	Making Markets Work for the Poor
MAEP	Mymensingh Aquaculture Extension Project
MES	Meghna Estuary Studies
MIS	Management Information System
MMS	Manob Mukti Songstha
MODMR	Ministry of Disaster Management and Relief
MOF	Ministry of Finance
MOFL	Ministry of Fisheries and Livestock
MoLRD&C	Ministry of Local Government, Rural Development and Cooperatives
MoU	Memorandum of Understanding
MPRVD	Multipurpose River Valley Development
MRP	Main River Flood and Bank Erosion Risk Management Project
MSP	Maxwell Stamp PLC
NAM	Non-Aligned Movement
NCA	National Char Alliance
NGOs	Non-Government Organizations
NSPS	National Social Protection Strategy
OXFAM	Oxford Committee for Famine Relief (Founded in 1942)
PA	Practical Action
PKSF	Palli Karma Sahayak Foundation
PMG	Producer and Marketing Group
PO	Presidential Order (1972)
PRA	Participatory Rural Appraisal

PSF	Pond Sand Filter
RCS	Red Cross Society
RDRS	Rangpur Dinajpur Rural Services
REIS	Riverbank Erosion Impact Study
RFLD	Regional Fisheries and Livestock Development
RFLDC	Regional Fisheries and Livestock Development Component
RIMES	Regional Integrated Multi-Hazard Early Warning System
RLGS	Rural Local Government System
RS	Remote Sensing
SDGs	Social Development Goals
SKS	SKS Foundation
SLDP	Smallholder Livestock Development Project
SLR	Sea Level Rise
SOP	Standard Operating Procedure
SRI	System of Rice Intensification
SSNP	Social Safety Net Programs
STW	Shallow tube well
SWC	Storm Warning Centre
SWFF	Securing Water for Food
TSU	Technical Support Unit
UMC	Upstream mid-channel chars
UMIC	Upper Middle-Income Country
UN	United Nations
UNESCO	United Nations Educational, Scientific, and Cultural Organization
UNHCHR	United Nations High Commissioner for Human Rights
UNICEF	United Nations International Children's Emergency Fund
UP	Union Parishad
UPDMC	Upazila Parishad Disaster Management Committee
USAID	US Aid for International Development
USD	United States Dollar
USS	Udayan Swabolombee Sangstha
UTC	Coordinated Universal Time
VDCs	Village Development Committees
VGF	Vulnerable Group Feeding
VPISU	Virginia Polytechnic Institute and State University
VSL	Village Savings and Loan
WARPO	Water Resources Planning Organization
WASH	Water, Sanitation and Hygiene
WWII	Second World War

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Part I
Introduction

Chapter 1
Background, Approach, and Issues

Mohammad Zaman and Mustafa Alam

Abstract Chars in Bangladesh, emerging from sandy and alluvial deposits across the floodplains and the estuary, constitute an important part of the landscape and ecology of the country, with significant marks in its history and heritage. An estimated 20 million people in Bangladesh live in these chars, which remain isolated and deprived of numerous essential services. Char dwellers are mostly poor and highly vulnerable to natural hazards of flood and erosion. In addition, the coastal chars are faced with the prospect of widespread inundation due to the impending sea level rise, consequent upon climate change in the region. The development prospects for floodplain and the delta, inclusive of the chars, have traditionally been considered more in terms of physical/infrastructural development, without adequate attention to the diverse socio-economic and institutional needs of char communities. It is hoped that this book, with its comprehensive coverage of the physical, ecological, socio-economic and institutional issues, would provide a better understanding of the complexity of char life, its constraints and development potential, thereby helping policy planners and implementers at different levels in effectively contributing to char development in an integrated and sustainable manner.

Keywords Floodplain · River systems · Estuary · Alluvial deposits · Charlands · Flood · Erosion · Displacement · Char development

Introduction

In Bangladesh, chars are an important part of the landscape and ecology, having made significant marks in its history and heritage. Upward an estimated 20 million people live in chars in the floodplains of the major river systems and in the coastal regions

[1] Danish International Development Assistance.

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of the country. These chars continue to remain isolated, deprived of services, and pockets of poverty in the country. Char dwellers, by and large, are poor and highly vulnerable to natural hazards of flood and erosion. In addition, the coastal chars are faced with the prospect of an impending hazard of inundation due to sea level rise, consequent upon climate change in the region.

Development prospects for the floodplains and the delta, inclusive of the chars, in Bangladesh have traditionally been considered more in terms of physical/infrastructure development. The focus on socioeconomic and institutional needs for char communities is gaining ground with time, as evidenced by initiatives like the Chars Livelihood Programs (CLP), the Char Development and Settlement Project (CDSP), the Livelihood Program by DANIDA[1] in the Meghna Estuary and similar other programs undertaken by local and international non-government organizations such as the Rangpur Dinajpur Rural Services (RDRS-Bangladesh), Practical Action (PA-Bangladesh) in Rangpur and Dinajpur districts in the Brahmaputra floodplain. The social and development works carried out to date in the chars have raised many issues with regard to disaster responses, preparedness, coping strategies, resilience/adaptation, agricultural adjustments, and land rights issues, particularly administration of alluvial and diluvial lands in the floodplains.

The aim of this collection is to advance critical scholarship on chars and char development in Bangladesh. The contributors to this volume address a broad range of topics from disaster responses to displacement, resettlement, and intersections of economic, cultural, political, legal, and gender/social realms in historical, contemporary, and in local ecological contexts. Several of the authors looked at the delta frontiers and charland with new insights and theories using frameworks that integrate ecological and political economy approaches for understanding the dynamics of char societies.

The River Systems, Floods, and Erosion in Bangladesh

The rivers of Bangladesh are the most unique features of its landscape. With a network of some 250 rivers, Bangladesh occupies most of what is known as the Bengal delta, the largest delta in the world.

The delta country is largely made up of alluvial soil deposited by the three main river systems—the Ganges, the Brahmaputra-Jamuna, and the Meghna rivers (Fig. 1.1). The Ganges originates in the southern slopes of the Himalayas and enters Bangladesh near Rajshahi (Ahmed 1968). It flows southeast to its confluence with the Brahmaputra, from where it is known as the Padma. The Brahmaputra originates in the Himalayas in China and flows through Tibet and India into Bangladesh. It is known as the Jamuna from its confluence in north Bengal with the Teesta (Rashid 1978). The Meghna rises in the rainiest hillslopes of the world—the Shillong Plateau in Assam and joins the Padma south of Dhaka, the capital of Bangladesh. The major rivers and their distributaries criss-cross the country, annually flooding nearly all of the delta.

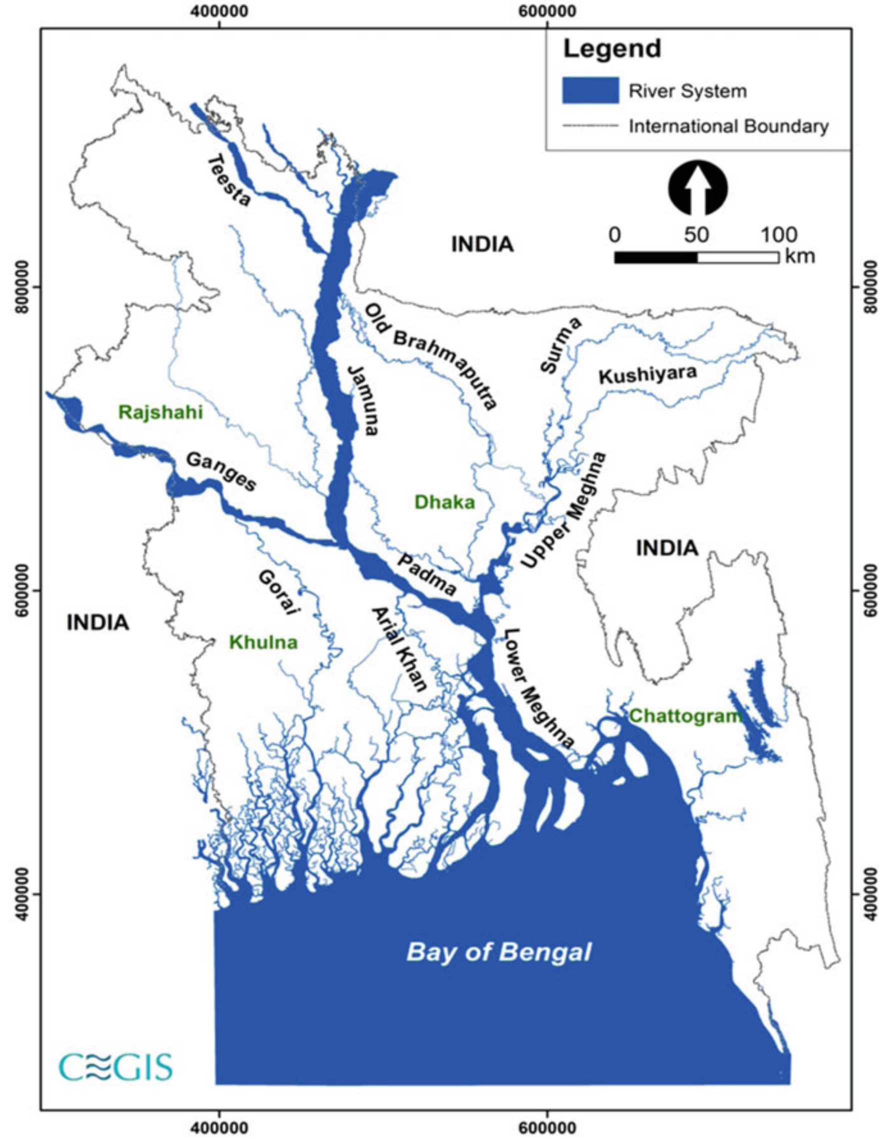

Fig. 1.1 River systems of Bangladesh

The annual flood, between June and October, associated with the monsoon rains, makes the land fertile by providing moisture and fresh silts conducive to agricultural production. However, high floods can be the cause of widespread destruction of crops, properties, and even loss of human life (Paul 1984). In the past, such high floods in the country used to occur once every ten years or so; however, more frequently occuring high floods of recent times (2017, 2019 and 2020) are alluded by some to be related to climate change in Bangladesh (Giovetti 2019).

Flood management in Bangladesh has historically been biased toward construction of large-scale flood control infrastructure like embankments and polders, without due attention to socio-economic, demographic and ecological considerations (see Rasid and Paul 1987; Zaman 1993; Haque and Zaman 1993; Hofer and Messerli 2006). Hofer and Messerli (2006) have pointed out that although flood is viewed as the "main problem" by authorities, significant numbers of people are more concerned with lateral river erosion, landlessness, and consequent economic destitution. The problem of bankline erosion received only minor attention from policy makers, and when it did, the focus was mainly on "structural" measures to control bankline erosions as opposed to approaches that are ecologically more sustainable (Zaman 1993; Haque and Zaman 1994).

Bankline erosion, caused by shifting of river channels, remains a perennial problem for Bangladesh. The multichannel braided and meandering river systems of the country, with their historic, gradual or sudden shifts in courses, have eroded large tracts of land in the past, routinely creating and recreating numerous chars in the process of erosion and accretion (Elahi et al. 1919). The most erosion prone districts in the north are Rangpur, Gaibandha, Kurigram, Bogra, Jamalpur, Tangail, and Sirajganj; other erosion prone districts along the Jamuna banklines include Faridpur, Rajbari, Shariatpur, Manikganj, Munshiganj, and Chandpur. The southern district of Noakhali and the coastal districts are also prone to severe erosion. Sirajganj and Kazipur in the Brahmaputra-Jamuna floodplain is one of the most erosion prone areas of the country; nearly 50% of the land area of Kazipur Upazila has been eroded over the last 40 years or so (Zaman 2019a). Unfortunately, there are no reliable up-to-date data on the number of people displaced by erosion in the country. There are an estimated 300 erosion prone locations in the country and hundreds of villages, markets, and towns along the 2,400 km banklines are liable to annual erosion (Zaman 1988, 2019b). The banklines include much of the most densely populated land in the country, it is estimated that somewhere between 10 and 15% of population of Bangladesh live in areas exposed to erosions (Haque 1988). As a result, a large number of people in the country are continuously at the risk of displacement.

It is important to adopt a long-term holistic approach in dealing with the flood and erosion problems of Bangladesh, taking into account how communities have traditionally organized themselves and survived in the face of these physical calamities. Only through such a comprehensive approach can one hope to achieve the goal of char development in the country.

Chars and Char Regions

It is to be noted that erosion leads to creation of new lands by way of accretion, known as chars in Bangladesh, which are considered by many as newly available resources for survival in the floodplain and the delta. Erosion and accretion are thus two parts of the same process; what goes down eventually reappears, though it is difficult to foresee the spatial or temporal connotations of the process. In most instances, the newly emerged chars are immediately put to use by people from neighboring chars or mainland, not without disputes over use and/or ownership rights. For peasants without land, the new chars are a means of survival and a source of living, who quickly move to these new "frontiers" with their herds and build temporary shelters for grazing and cultivation until they stabilize or in some instances, they disappear again into the river (Zaman 1991).

The chars constitute nearly eight percent of the total land area of Bangladesh. There, however, are different types and sizes of chars. In this volume, authors have referred to chars as islands or channel bars, in the case of coastal chars as well as chars in the floodplains. Some chars are vegetated while others such as sandbars are typically flooded; the sandbars are visible and put to use only during the winter/dry season. There are also chars contiguous to riverbanks, called attached chars, often indistinguishable from the floodplain. For the purpose of this book, the term char or charland includes a broad range of different forms of sandy and alluvial deposits in the river floodplains and estuary (FAP 1993). As a dynamic process, many of the sandbars or temporary chars continue to grow with additional accumulations of sands and silts over the years. In sum, chars refer to all alluvial deposits—large or small, temporary or permanent—either in the river or close to the banklines.

Academics and experts (Sarker et al. 2003; ISPAN 1995) divide the charland—from Chilmari in the north to chars in the southern estuary—into five regions (Fig. 1.2). The Index Map of the Char Regions, prepared by CEGIS (December 2020), identifies the various regions that include: (i) Teesta-Jamuna (A, C); (ii) Brahmaputra-Jamuna (B, C, E); (iii) Ganges (D, E); (iv) Padma (E, F); (iv) Lower Meghna (F); and (v) Meghna Estuarine chars (G).

Has the char area increased or decreased over time? As evident from Fig. 1.3, the area of charlands has remained more of less the same with slight variations over a 20-year period from 2000 to 2020 across the five regions.

According to one source (https://en.banglapedia.org/), the braided Jamuna has 56 large chars and 226 small sandy and vegetated chars. The Padma has a total of 13 large and 18 small island chars. The chars in the Upper Meghna are very old and stable; those in the Lower Meghna at the confluence with the Padma are large and wider. The estuarine chars in the Bay of Bengal are very different in formation and character from the riverine chars abounding in the Ganges, Brahmaputra-Jamuna, and Meghna floodplains. While there are more island chars in the estuary, a higher incidence of attached chars can be found in the meandering Padma River. The Jamuna chars, particularly in Kazipur-Sirajganj area, are largely island chars in between channels. Some of the island chars are old and long-standing—for instance, Char Janajat located upstream from the Padma Bridge site (see Chap. 12).

Typically, char village settlements consist largely of in-migrants from neighboring chars or mainland villages displaced by erosion. There is an ever present competition among these people for access to and control over charland. The new chars are a source for living and survival; however, the inhabitants there often need to move from one char to another in their precarious bid for survival (Zaman 1989). It is to be

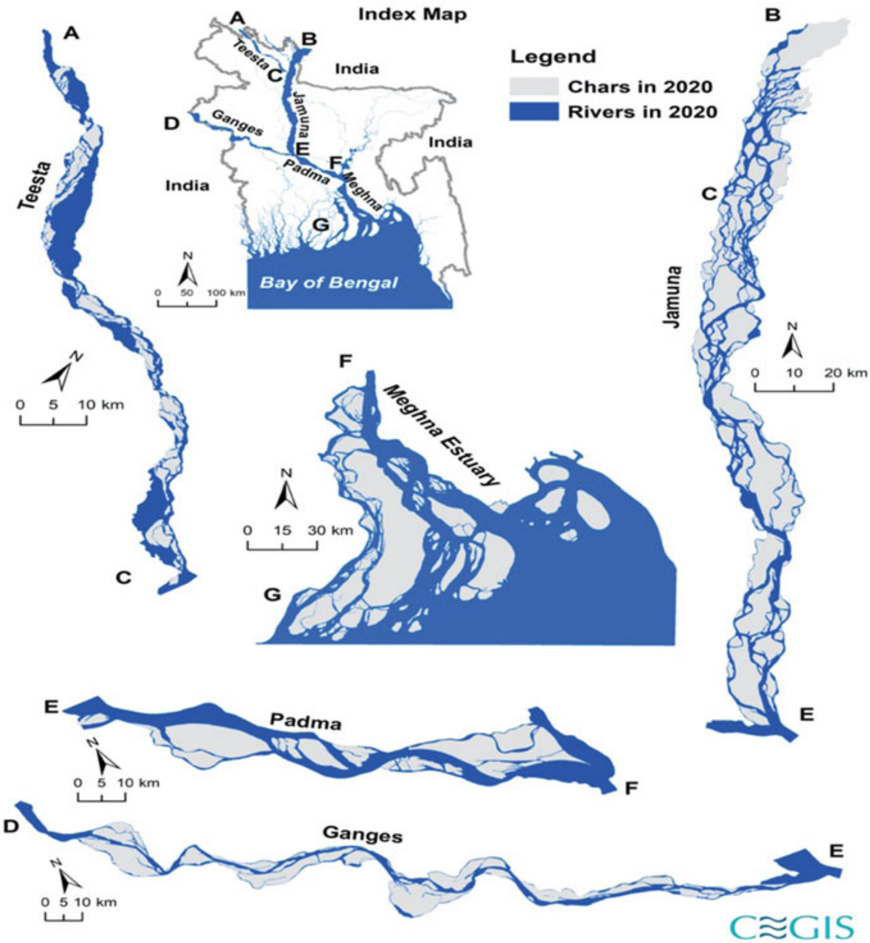

Fig. 1.2 Index map of the char regions, 2020

noted that despite apparent isolation, char life in Bangladesh continues to be socially, economically, and politically integrated with the mainland and the larger society.

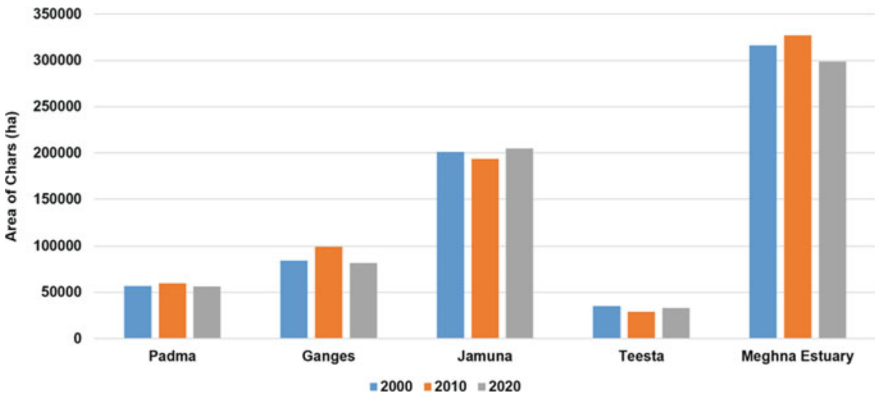

Fig. 1.3 Area of charland (in ha) by region 2000–2020. *Source* CEGIS, December 2020

About the Book

For many char dwellers, their precarious existence on the mostly elusive land is characterized by a day-to-day struggle for survival. There is a need for looking at the context of char development more holistically with a new set of policies, programs, and institutions. The *1st Char Convention of 2015* came out with a 14-Point Declaration that included proper infrastructure, healthcare, education, safe drinking water, skill development/livelihood support, mainstreaming gender in char development, social safety net program, new land laws for chars, distribution of khas land to genuinely poor char dwellers, and a national char foundation to strengthen the development of char communities and to formulate a char development policy (Krishibid Institution 2015).

The book has brought together diverse scholarship on char and its people, covering the physical and technical, as well as the economic, legal, and social aspects toward establishing a development agenda, based on an integrated and holistic approach.

The book is structured in seven parts. Part II—"The Delta and the Charland"—deals with historical dynamics of the development of settlements in the delta frontiers and charlands. It includes a theoretical discourse, suggesting a paradigm shift from the conventional water-land binary surrounding charland erosion and accretion. Finally, there is a discussion on char dwellers' right to development in Bangladesh. Part III on "Chars in Bangladesh: The Geo-Physical Context" has dealt with geomorphology of the riverine and estuarine chars in detail, making use of remote sensing and other data. The processes related to erosion, sediment transport and deposition are discussed at some length. There also is an exposition of the soil types in five different char regions of the country. Besides, it includes an evaluation of future risks of climate change impacts on riverine and coastal chars in Bangladesh.

The subject matter of Part IV is "Flood and Erosion Disasters: Coping Strategies and Survival," which examines the responses and coping strategies by the char dwellers, including adaptation to flood and erosion. There is a discussion on human responses and adjustments to displacement in the Brahmaputra-Jamuna floodplain and the Lower Meghna estuarine chars. An evaluation of the role of non-government organizations (NGOs) presented. Also included is a discussion on flood proofing measures comprising minor structural and a range of non-structural measures in mitigating the adverse impacts of floods.

Part V, "Livelihood Vulnerability, Adaptation and Gender Dimension," discusses the vulnerabilities faced by char people in agriculture and crop production and the adaptation measures taken by them to minimize risks and reduce losses. There are discussions on periodic and cyclical out-migration from char areas due to various push and pull factors. It also includes deliberation on gender issues in the context of chars, highlighting aspects that are in need of immediate attention.

Part VI is on "Case Studies of Major Experiments in Char Development," where discussions are undertaken on the experience of the Chars Livelihoods Program (CLP), of the Char Development and Support Project (CDSP) and the Sandbar Agricultural Technology is pursued in some chars in the country. Livelihood development in coastal chars in the Meghna Estuary is also discussed at some length.

Issues of "Char Administration and Governance" are taken up in Part VII. It provides an overview of the legal framework, arguing for improving upon the existing legal framework, settlement policy, and institutional arrangements for char development. Competing discourses on bank protection and erosion management are presented and suggestions made for an inclusive char development strategy. The authors call for a comprehensive set of medium- to -long-term strategy and action plan for more inclusive char development.

Finally, Part VIII, the "Summary and Conclusion" underscores the need for learning lessons from past experience. It calls for adoption of a holistic approach toward char development in Bangladesh, which can provide the char dwellers with a sustainable life and dependable livelihoods in the uncertain terrains they live in.

Contributions of the Book

This volume is a comprehensive collection of chapters written by a multidisciplinary team of experts, covering various aspects of char life. With a wide coverage of the physical, ecological, socioeconomic, gender, and institutional issues, it is hopeed that the book would provide a better understanding of the complexity of char life, its constraints, and development potential.

This book is purported to enhance the understanding of char issues and needs of the char people in Bangladesh. The aim has been to reach out to all stakeholders interested in char development in the country. It is hoped that the book, with its multidisciplinary approach and breadth of coverage, will stimulate further interest in chars and char development among all relevant quarters, inclusive of policy planners and development practitioners.

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Part II
The Delta and Charlands

Editors' Note

Part II of this volume presents approaches to delta and charland studies that assess risks and deal with disruption of human lives and livelihoods that result from displacement caused by frequent events of erosion in the moving delta and charlands. The four chapters are a careful selection of contemporary literature on char studies and offer to a significant extent the basic framework of the book.

Mohammad Zaman and Mustafa Alam examine formation of the Bengal delta as frontiers for agricultural work, migration and demographic transition in historical as well as contemporary contexts, which continue to influence settlement patterns as well as access to and use of alluvial land in Bangladesh to this day. To Jenia Mukherjee and Kuntala Lahiri-Dutt, the small and unstable chars are powerful symbols of destabilization. The chars, they argue, demolish many widely held land-water binary views and advance alternative accounts, looking at land and water as hybrid environments, largely unstable and in a state of flux requiring those displaced to continually adjust to make the best of their local environments.

C. Emdad Haque and Mohammad Jakariya briefly explain characteristic features of the Bengal delta in terms of overall geophysical and hydrological system, followed by a discussion on responses of the delta inhabitants to the dynamic shifts of river channels. The analysis reveals how people living in the delta and the floodplains have historically adapted to the unstable and dynamic shifts of river channels and sustained their livelihoods within given physical constraints. Indrani Sigamany and Jay Drydyk anchor their chapter on UN Right to Development, focusing on the underlying causes of impoverishments of the char people, and conclude that their rights to development remain largely unfulfilled.

Chapter 2
The Delta Frontiers: History and Dynamics

Mohammad Zaman and Mustafa Alam

Abstract This chapter examines human settlement of the Bengal delta in historical and contemporary contexts. A discussion is undertaken on the rise of agricultural "frontiers" and settlements in the delta on the ever-shifting chars within the context of agrarian/economic activities, migration, and demographic transition. Today, the alluvial chars in Bangladesh constitute sort of an "endless" agricultural frontier. The chapter briefly describes the socio-economic and political practices of settlement and access to the dynamic frontiers, and how people have traditionally made use of the newly accreted land. An attempt has been made to highlight the issues of management and administration of alluvial land through the colonial and post-colonial periods, which continue to influence the patterns of settlement, use, and access to alluvial land in contemporary Bangladesh.

Keywords Bengal delta · Frontiers and settlements · Dynamics of char life · Resilience and adaptation

Introduction and Objectives

This chapter examines the process of human settlement of the Bengal delta in historical and contemporary contexts. The Bengal delta has been viewed as an agricultural "frontier" in illustrating the experience that people living on these ever-shifting chars have gone through in the context of regional settlement, agrarian/economic activities, migration, and demographic transitions. By definition, a frontier refers to a region on the edge of settlement, a political/geographic area near or beyond a boundary. The concept of frontier by Turner (1893) points at the availability of unsettled land for expansion. Lattimore (1951) examined the effects of the frontier status on the history and development of many East Asian countries. This concept is useful in viewing the charland as a "frontier space," notably because people there are living on the edge,

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where the land is in a continuous state of flux, appearing and disappearing, yet these hinterlands are providing life and livelihood to millions. It is hoped that the historical perspective presented in this chapter would provide the backdrop necessary to appreciate the theoretical and empirical discourses in the chapters to follow in the book.

The alluvial chars in Bangladesh constitute a sort of "endless" agricultural frontier. Land is continuously created and withered away by actions of the river. Land erosion on one side of the river may at some point in time be followed by accretion of land on the other side or downstream alongside some other village. In this context, pertinent questions are, who should own the newly appearing land? How should such land be settled and used? This chapter purports to describe the socio-economic and political practices of settlement and access to the dynamic frontiers of the newly appearing land, often marred by disputes among communities in such riverine areas. In doing so, the focus has been on the management and administration of alluvial land through colonial and post-colonial periods as well as the socio-economic, political, and cultural practices by which people living on the charlands continue to gain and maintain access to the new land.

Brief references are made to other deltas such as the Ayeyarwady Delta in Myanmar, the Mekong Delta criss-crossing Thailand, Laos, Vietnam and Cambodia and the Kaveri delta in South India. These deltas share certain similarities with regard to their colonial and agrarian history and development. The Ayeyarwady Delta, for instance, developed as one of the largest rice exporting regions of the world during the British colonial rule from 1852 to 1948 (Adas 1974). Van Schendel (1991) provides an excellent analysis of the rise and fall of agrarian elites in the predominantly rice economies in the three deltas—Lower Burma (now Myanmar), Bengal delta, and the Kaveri delta in South India—over a period of 200 years of British colonial rule and its aftermath. There has not been much of an attempt to date at exploring in a multidisciplinary manner the system of alluvial land management in Bengal delta in historical and contemporary contexts, with an analysis of the development of settlement and agricultural practices in the newly emerged lands. This chapter seeks to fill this gap by looking into the dynamics of access, exploring as to who benefits from the newly appearing land in terms of settlement and/or cultivation. Particular attention is paid to land settlement and colonization during the British period and the land tenure system established with regards to use and access to alluvial land.

Background and Approach

This chapter is primarily based on secondary literature. It brings together and examines colonial reports/records (Hunter 1875, 1877; O'Malley 1923), historical accounts (Pargiter 1885; Carstairs 1895), geographical exposure (Ahmad 1968; Rashid 1978), socio-economic history (Jack 1916; Mukerjee 1938) and comparative social-anthropological discourses (Nicholas 1962; Zaman 1988, 1989, 1991; Haque and Zaman 1989; Haque 1988; van Schendel 1991;Lahiri-Dutt and Samanta

2013). The analysis is further flourished by Zaman (1988; Zaman et al. 2019) on the Brahmaputra-Jamuna floodplain, dealing with char settlement and social organizations, examining how these have been shaped by the colonial and post-colonial land tenure system and administration of alluvial charlands in the country (also, see Chap. 4). Thus, using historical data, the chapter offers a socio-economic analysis of the rise of settlement and use of newly emerged charlands of the Bengal Delta. The early frontier-like character of the delta/chars in Bangladesh—i.e., settling on newly formed alluvial lands and cultivating various crops there, often by pacifying opposing forces and managing subtle collaboration with local administration for maintaining access to the land, all of which constitute a process of struggle, is key to a better understanding of the access/use of the newly formed land, as well as its management.

Discourses on Delta and Alluvial Lands: Ecological Changes and Struggles

Deltas are often described as cradles of civilization. Today, over 500 million people live in river deltas around the world (Krause 2017). The history of a delta portrays the dynamics of interaction among water, emerging land and the settlers, with the stability of land being periodically threatened by erosion. The socio-economic and cultural dimensions have been missing in many conventional delta studies, which have focused more on geomorphological issues concerning land and water. In recent years, some scholars have taken a different stance than this water-land "binary" or dualistic approach in geography with alternative accounts of "hybridity" (see Lahiri-Dutt 2014; also Chap. 3); others have come up with a more ethnographically grounded approach, illustrating the dynamic interaction between local and external forces shaping the settlement of alluvial land (Ivars 2020; Bhattacharyya 2018; Lahiri-Dutt and Samanta 2013; Zaman 1991; Haque and Zaman 1989).

Krause (2017: 404) discusses the concept of "hydrosociality"—suggesting that "the study of delta life, social relations must not be seen as add-ons … [to any] hydrological backdrop…and must be approached through their engagements in social, political and economic relationships." He goes on to explain what he coined as "amphibious anthropology"—the "study of social and cultural life that takes into account its relations with the muddy ambivalences of delta environments" (Kraus 2017: 403). The threads of this hydrosociality framework come from the classic work by Wittfogel (1957), *Oriental Despotism* that links water control with political power and state system. In a similar fashion, Biggs (2010) described the long-term impacts of environmental and infrastructural transformations within the Mekong Delta in Vietnam. Morita and Jensen (2017: 118), using Chao Phraya Delta in Thailand as a case study, further explored contrasts between "terrestrial" and "amphibious" ways of looking at water and interventions—the former "originated in Europe and focused on removing water for agriculture, the latter conceived of deltas as extending water flows."

Scott's (2009: 13) seminal work on Southeast Asia further illustrates the relative isolation of much of the land mass from government control that constitutes "one of the largest … nonstate spaces in the world." Scott demonstrates how local ecology influences and determines structural relationship with nation states. While the task here is not to examine the processes of state building in deltaic environment, it is useful nevertheless to understand the processes and patterns of negotiations and the nature of interactions and transactions with the state system—beyond the chars with the political processes and administration of charlands in the country. A discussion on the local ecology, social structure, and processes should help in understanding the development of the frontier in terms of local cultural practices and relationships with the mainland administration and socio-economic and political systems. The primary question then, following Krause (2017: 403), is "what does it mean and what does it entail socially, to be a delta inhabitant in the twenty-first century?" This is explored throughout the book in search of an ecologically sound and integrated approach that considers alluvial land resources and the economic, social, and environmental needs of the char dwellers in the deltaic lands of Bangladesh.

The Moving Lands of the Bengal Delta

Deltas are formed as a result of unique interaction between rivers and tidal processes (see Chaps. 8 and 9). The fertile lands of the delta and the floodplains support agriculture and food production. The Bengal delta, which is the largest and most populous active delta in Asia, also known as the Ganges delta, includes the deltaic portion of the Indian state of West Bengal and all of the deltaic and the coastal plains of Bangladesh, including the tidal plains of the southern part and the Sundarbans. Spate (1954) divides the Ganges delta into three regions: the Moribund, Mature, and Active deltas. The Moribund is the oldest portion of the Ganges delta formed by the silt of the Ganges and its distributaries (Fig. 2.1).

The active Bengal delta roughly covers the deltaic and coastal plains of Bangladesh. The tidal plains of Barisal, Patuakhali, Khulna, and the Sundarbans in the southern part of the country facing the Bay of Bengal characterize the active delta area (Banglapedia 2018). However, due to the action of tides in the coastal plain, extending from Noakhali to the south of Cox's Bazar, the entire southern face of the sea is considered part of the active delta. Thus, the larger deltaic region is formed by portions of Comilla, Dhaka, Faridpur, and Noakhali districts in the Padma-Meghna floodplain and the coastal belts of Chittagong along with the Karnaphuli river system.

The deltaic plain is subjected to regular flooding and continuous erosion and accretion; new strips of land appear as quickly as the old ones disappear within the river. Likewise, alluvion and diluvion are continuous pheneomena in the Brahmaputra-Jamuna floodplains, leading to emergence as well as disappearance of new chars every year. Erosion and accretion in the lower Meghna are governed by upland

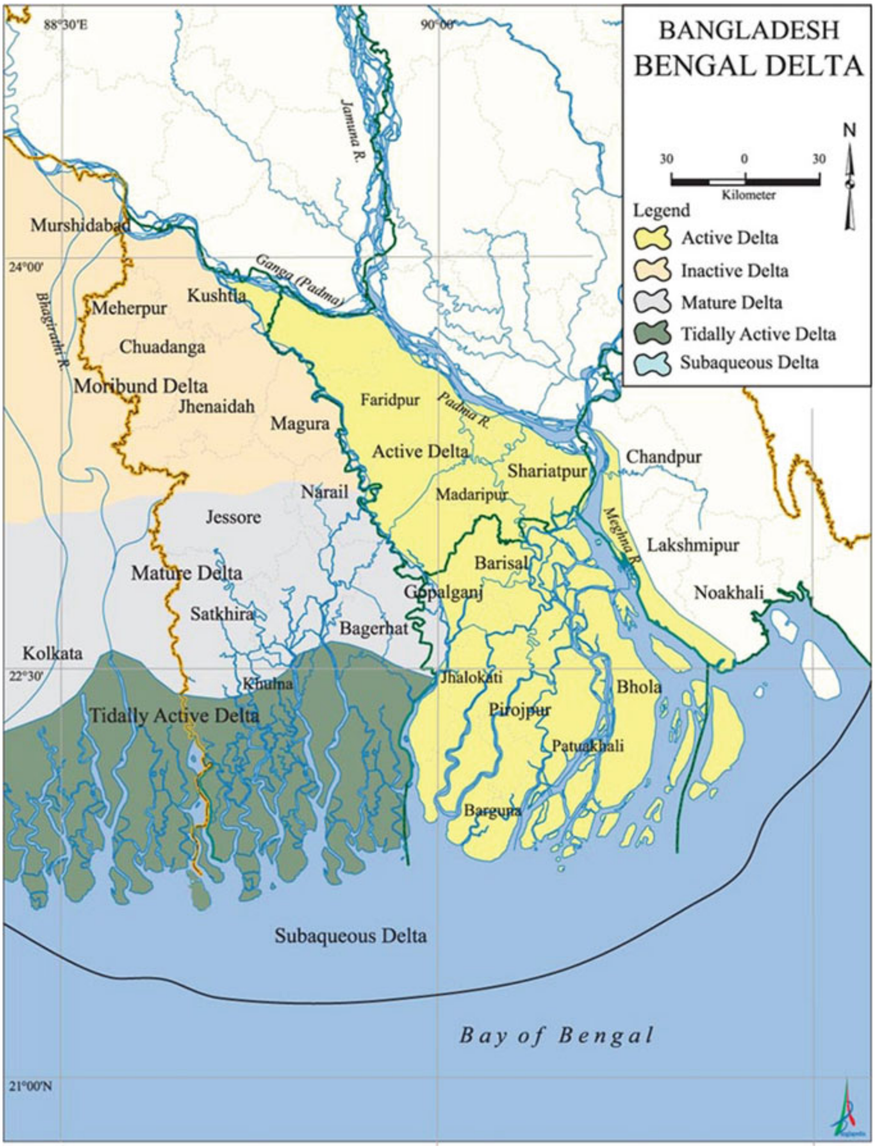

Fig. 2.1 Map of the Bengal delta. *Source* Banglapedia 2018 (https://en.banglapedia.org/)

discharge of the Ganges–Brahmaputra–Meghna river systems, and tidal influence of the sea. An estimated 2.0 billion tons of silt is annually carried through the Ganges–Brahmaputra–Meghna river systems, into the Bay of Bengal. The char development and settlement project (CDSP) in the Lower Meghna estuary has resulted in the development, stabilization, and settlement of many chars in the estuary (see Chap. 22).

The Brahmaputra-Jamuna floodplain covers a large territory, extending from the northeastern tip near the Teesta through the main channel of Brahmaputra-Jamuna, to the Meghna. The floodplain is subjected to large scale inundation by flood water (between three to twelve-feet) during the monsoon season from mid-June to mid-October every year (Rashid 1978). The most extensive recorded shift of the Old Brahmaputra River in 1787 into its present Jamuna channel brought remarkable fluvial changes occuring in the Brahmaputra-Jamuna floodplain over the last two hundred years (Ahmad 1968; Bristow 1987). Hunter (1887: 385) describes the Brahmaputra-Jamuna as "a river of many changes. After the mapping and survey of 1850–56, it swept eastward and washed away several villages on the bank of the river; but afterward retired toward the west forming a new channel." O'Malley (1923: 6–7), in his *Bengal District Gazetteers: Pabna*, made the following remarks:

> Alluvion and diluvion are constantly taking place along the courses of the principal rivers of the district, especially the Padma and the Jamuna, the river channels perpetually swinging from side to side of their sandy bars, while the streams themselves sometimes completely change their courses... The surface of the country in the neighbourhood of the great rivers is thus subjected to constant changes, which naturally give rise to innumerable disputes over land.

One of the far reaching fluvial changes in the Brahmaputra-Jamuna system over the years has been the emergence of new chars in the floodplain. These changes in the river systems have influenced human settlement and the way of life of the people in the Bengal delta from time immemorial (Mukerjee 1938). Chowdhury (1982: 11) remarks that "the history of low-lying land can be traced and found in the morphological evolution of the river systems."

Land Reclamation and Settlement in the Delta Frontier

The first settlement of Bengal was in the old alluvium tracts. Mukerjee (1938: 123–130) writes:

> The most ancient inhabitants were described as fishermen and uncleaned folks in the ancient literature... Vanga at that time comprised only the modern districts of Murshidabad, Nadia [now in West Bengal], Jessore, Pabna, Faridpur and parts of Rajshahi [in Bangladesh]… It is probable, however, that only the riverine tract or the seaboard was populated; the interior was more or less a region of marshes and wastes devoid of habitations. Barani, writing as late as the 14th century, thus refers to Bengal as a "land of swamps."

Jack (1916: 16–17), a colonial officer who spent years in Faridpur District of Eastern Bengal, describes the development of settlement in the delta:

> It is still in the process of formation and is full of rivers which are broad and deep, heavy in the flood season with constructive silt, yet sufficiently active to work their will upon a land of plastic mud. Here, as is the fashion of the delta, the rivers are washing away mud from

> one bank and re-forming it on the other with method so complete and comprehensive that in the entire tract, perhaps 900 square miles in extent, very little of the present land has been in existence a hundred years and not very much for more than fifty years. Probably there has been land and population in all this country for five centuries or more....It is only within the last century that the population has flocked to this basin, but to such purpose that the dismal swamp now contains 800 people to the square mile.

Many historical accounts (Hunter 1877; Pargiter 1885; Carstairs 1895) report that the new delta areas and also a large part of southern Bengal including the Sundarbans constituted a "new frontier" in terms of migration, extension of cultivation and development of new settlements. Mukerjee (1938) identified, among other, population pressure in the decaying moribund floodplain vis-à-vis the availability of extremely fertile alluvial soil and opportunities provided by rivers for transport and commerce as factors for migration into the new delta areas. These observations on population settlement in the delta have been confirmed by Nicholas' (1962) comparative study on the evolution of village organization in the old and new delta area. Nicholas (1962: 80) remarks:

> Population pressure and competition for land in the older settled portions of the delta forced groups of poor cultivators to search for new land in the south and east, to take their families into the newly opened territory, and to develop new communities there.

The fact that the riverine environment and new land resources attracted settlers from other areas has been further established by Haque (1988), comparing population density between bankline and non-bankline districts in the Brahmaputra-Jamuna floodplain over a period of about one hundred years from 1891 to 1984. The districts on the bankline have had consistently a much higher density of population than the non-riparian districts. Haque (1988) explains this variation between the two broad regions largely as a product of past population redistribution caused mainly by migration to the new delta area. This higher density in the riparian districts was also aided by ease of water way transportation that led to faster and higher growth rate in these districts (Mukerjee 1938).

Processes of Settlement

Two different processes of settlement on land are identified historically: (i) land reclamation, clearing and cultivation, especially in the fringes of the Sundarbans, and (ii) claims over newly accreted land or depositional land by peasants in the riparian areas of the active river system. The Sundarbans, an extensive mangrove forest lies "in the southern portion of the Ganges delta, extending from the Hugli on the west to the Meghna on the east, through the present districts of 24-Parganas [West Bengal], Khulna and Bakarganj [in Bangladesh]" (Pargiter 1885: 1). It is found in historical records (Hunter 1875; Pargiter 1885) that the Sundarbans had constantly attracted settlers during the last two hundred years, who opened up new frontiers of settlement at its northern edge by reclaiming land through clearing jungles and building embankments. Hunter (1875) reports that the *zamindars*, in order to extend their untaxed domain, introduced tenants (*abadkari* or reclaiming *raiyats*), who led the clearing of forests and reclamation (also, see Gupta 1940). The *zamindars* in the Sundarbans regions had two major objectives in land reclamation: control of additional tax-free land and appropriation of surplus from their tenants who turned the waste land into productive asset. Thus, the reclaiming *raiyats* were a distinct social category in their relationship with the *zamindars*, who controlled the reclaimed land. Settlement and ownership rights over newly accreted land in the active river system raised similar legal issues (see Chap. 4).

Contemporary Settlements in the Floodplain and Meghna Estuary

The newly emerged chars, despite being vulnerable to erosion and flooding, are settled by peasants having no land of their own elsewhere to provide them with a source of living. When new land emerges, needy people often rush there and put it under cultivation. This often led to competing claims by inhabitants of neighboring settlements struggling to gain access to the new land (Zaman 1987, 1991). Such precarious way of life and survival in the chars have been historically shaped by the legacies of colonial and post-colonial land laws, particularly laws related to erosion and use of newly accreted lands in the country. By their constant state of flux, alluvial land raises specific challenges to laws, policies, and practices with regard to ownerships of new lands. Successive pieces of legislations in Bangladesh have continued to legitimize unauthorized and forceful claims over land in many instances (see Chaps. 4 and 24). Thus, in the unstable charland environment that makes the "frontier", access to newly emerged lands are determined by law and other modes of use of land in local context.

In contrast to the floodplain scenario, a planned experimental char development and settlement project (CDSP)[1] in the Meghna estuary provides a "good practice" alternative (see Chap. 22). The new charlands, once stabilized, are settled by pre-selected landless households, with land rights/titles and provision of certain internal infrastructure support (such as polders, cyclone shelters, roads, ponds, tube wells) as well as support in agricultural development. The planned and combined interventions by CDSP, with support from various government departments and NGOs, have led to socio-economic transformation in a number of coastal chars with substantially improved livelihoods for the settlers (Shahed et al. 2016). All this important lesson should be kept in mind in the context of char development in Bangladesh.

[1] Char Development Settlement Project (CDSP) was initiated in 1994, of which the fourth phase of the project is currently underway (see Chap. 22).

Concluding Remarks

Human settlement in the Bengal delta has traditionally been associated with physical vulnerabilities of flooding, erosion, and storm surges. Imminent sea level rise due to climate change and the inundation thereof adds an extra dimension to these threats. According to available reports, climate-induced hazards would in all likelyhood disproportionately affect those living in riverine and coastal chars (see Chap. 11). In addition to addressing these physical threats, it is necessary to adopt an approach that can integrate the essential ecological processes, human settlement issues, agricultural needs, and an improved land tenure system, all aimed at reducing vulnerability and enhancing quality of life for the char dwellers in Bangladesh.

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Chapter 3
South Asian Chars as Destabilizers

Jenia Mukherjee and Kuntala Lahiri-Dutt

Abstract Many researchers have studied chars as physical and geomorphological entities and have categorized them into various 'types'. This chapter asks: 'Can chars be seen also as symbols?' 'What do the chars symbolize?' We investigate these questions in this chapter, in light of recent social science research that has critiqued the inherent scientism on which many such studies are founded. In particular, we argue that the small, unstable and impermanent chars are powerful because they are symbols of destabilization. By their very existence, chars demolish a number of dearly held scientific concepts and ideas. Of these, the idea of rivers as carriers of only water is one. Chars also subvert the notion of people as essentially sedentary and land as permanent and safe, and disrupt the view of land and water as two fundamentally separate physical elements of nature. Finally, and most crucially for their futures in the increasingly uncertain world, chars and the lives of people who live on them also dislocate the notion of 'adaptation', by showing that people on chars are continually adjusting on a daily basis to make the best out of their local environments. We deploy 'chars as destabilizers' as the theoretical traction to complicate meanings and perceptions across 'stable' and 'unstable' in environments to underline that such environments and habitats are in a continual flux.

Keywords Char · River Islands · Destabilizer · Instability · Fluidscapes · South Asia

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Introduction

> In our age of shifting baselines and unstable climate, the ground beneath our feet seems unreliable. Melting icecaps, tsunamis, and warming water temperatures are eating away at our ideas of stability. But in some places, the ground was never quite stable in the first place. On the seashores and on the coastal lowlands, the ground is a half-liquid, seeping, shifting edge between land and water: a mutable boundary of mud, sand, and silt. People have lived on these littorals for millennia, adapting or rebuilding their settlements along with the flux of the tides and the movements of the land (Ritson 2019: 461).

Such are the damp ecology and fluid materialities of deltaic South Asia, inhabited by the most marginalized ecosystem-dependent communities. Neither river, yet part of it, neither the solid ground as we know it, yet usable, these liveable land, river islands, challenge, and also encourage us to revisit, the traditional theoretical understandings of the environment. They destabilize the notion of the environment comprising the distinct entities of land and water, of how people see risk and stability in making their livelihoods, and what they consider as adaptation to an uncertain, continually-changing environment. The river islands of South Asia are more vulnerable, though as a whole all coastal areas and low-lying islands remain susceptible to climate change in the Anthropocene. They experience development-induced displacement, lack of coordination among the administrative departments that work towards flood mitigation and disaster management, along with an overall apathy to find long-term solutions in tune to specific needs within political and geographical contexts.

There has been a plethora of research to understand these islands and island societies since the 1980s. Journals such as *Shima*, *Island Studies Journal* and *Urban Island Studies*, and organizations like the International Small Island Studies Association (ISISA) discuss issues such as ‘islandness, smallness, insularity, dependency, resource management and environment and the nature of island life.’[1] However, in spite of consolidation of the field of island research at the global scale, river islands hardly surface in island scholarship (Baruah and Mukherjee 2018). They exist ‘in the vocabulary neither of those who study rivers, nor those who study islands’ (Lahiri-Dutt 2014: 22). Even when the ‘blue hole’ in environmental history has been addressed (Gillis 2014), the ‘brown hole’ retains—larger than the ‘blue hole’, this pertains to the wider gap in literature on river and estuarine-deltaic islands.[2]

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[1] See https://isisa.org/. Accessed 26 June 2020.

[2] Gillis (2014) addresses the need to fill the blue hole in environmental history arguing that the sea remained underrated in societal discourses and historical scholarship. But though the blue hole gap was reduced with the contemporary spurt in island literature, riverine islands could not carve out the much needed space within this emerging scholarship. When Baldacchino (2006, 2006a) drew attention to the fact that the temperate and sub-arctic zones of the northern hemisphere, and not the tropics of the southern hemisphere, inhabit the world’s islands, Baruah and Mukherjee warned that ‘such a statement will provide much fodder to an already Eurocentric literature in island studies as well as fluvial geomorphology’ (2018: 324).

In this chapter we offer a comprehensive analysis of studies focusing on the South Asian river islands. We present theoretical scholarship on 'treacherous' landscapes—nebulous, transient, ephemeral environments in flux—that provoke scholars to find alternative frames of understanding and analyses to capture an array of attributes that define and characterize these water/landscapes. We deploy the notion of *char*s as destabilizers, critically probing into ideas of and boundaries between the 'stable' and the 'unstable'. Chars as destabilizers can be a powerful methodological tool, both literally and figuratively, destabilizing dominant hegemonic hydrology to further re-stabilize river–society relations by revering and reinvigorating (yet not romanticizing) instability as a way of living. The unstable chars, facing floods as a natural occurrence, forced livelihoods to live by the moods of the rivers (Lahiri-Dutt and Samanta 2007, 2013) until revenue-generating, profit-maximizing projects altered the nature and patterns of floods in these areas to transform them into more stable landscapes. These fluidscapes thus transformed from 'flood dependent' ecosystem regimes into 'flood vulnerable' landscapes (D'Souza 2003, 2006). These catastrophic implications provoked alternative framings, prompting 'wet' scholars to ponder the illusions and delusions of stability. Does instability infuse stability in these inherently unstable hybrid-scapes? How does one reinvigorate instability to reinforce stability in fluidscapes?

The absence of place-based knowledge and understanding due to the inadequacy of detailed studies on specific spatial (river island) sites along long-term temporal scales has ensured the continued legacy of the 'colonial hydrology' framework in shaping ideas, ideologies and actions on tropical-estuarine deltaic islands of South Asia. D'Souza (2006) conceptualizes 'colonial hydrology' to characterize modern British hydraulic interventions in South Asia, upsetting the age-old land–water equations and abstracting ecosystems from social and cultural contexts through foreign/European imported experience and expertise. When programmes and policies were implemented to control the floods, the deltaic South Asia was altered in ways that disrupted social lives and livelihoods on sediments (D'Souza 2006; Lahiri-Dutt 2000; Mukherjee 2018; Mukherjee and Ghosh 2020).

The emergence of the multipurpose river valley development (MPRVD) projects or dams in post-Independent India can be contextualized within the Western hydrologic knowledge and the larger politics surrounding the developmental discourse in decolonized contexts in the post–WWII scenario (D'Souza 2003; Escobar 1995). Large-scale development interventions in the form of dams and barrages have influenced patterns of riverine sedimentation with repercussions on the formation, consolidation and dissolution of river islands known in the Bengali local dialect as chars. The differentiated nature of development-induced formation–consolidation–dissolution of islands during more recent times has determined repetitive cycles of settlement–displacement–resettlement–re-displacement (SDRR) among islanders, in turn shaping vulnerabilities and adaptive practices among its people (Mukherjee 2011b).

Within the transforming context of global environmental change, Ritson (2019) aptly captures how efforts to stabilize the unstable are being scrutinized while acknowledging instability and impermanence as existential realities along lived temporalities:

> In recent centuries, human inhabitants have tried repeatedly to stabilize and expand the land by means of drainage and dikes, but rising sea levels and increasing storms (*and also aggravated floods as outcomes of these concrete measures of development*) are forcing a new appreciation of the dynamism of the coastal and fluvial lowlands (Ritson 2019: 461, *italics* in the original).

The emerging scholarship on South Asian river islands is scarce yet powerful. It fits well within the contemporary literature on hybridity, nebulosity and rhythmicity that explores water–sediment–society dialectics, expanding the ambit of water research by interpolating historical, political ecological and critical geographical perspectives. Moreover, the South Asian frame of analysis can be considered as a methodological intervention, formulating 'new epistemologies of water' which has potential to empirically inform, hence enrich, interdisciplinary cutting-edge river (water) research (Mukherjee 2020a).

Beyond Hard Lines: Wet, Damp and Fluid Ecologies

The definition of land in classical geography glorified land as the fundamental basis to pursue human activities, but omitted water**.** Geographers and geomorphologists, such as Carl Sauer, W.M. Davis and R. Hartshorne, conceptualized and explained land in opposition to water. In physical geography, however, land and water were defined as 'two completely separate entities' (Lahiri-Dutt 2014: 506). Categories like soil, territory, horizon, field, place, etc., were used in *association* with land, using vocabulary like frontiers, boundaries and borders, rim lands and peripheries.

European Renaissance led to the great divide between natural sciences and religious perspectives, and separated nature from society, land and water, as evidenced in Lafaye de Micheaux and Kull (2020). Modern technology, including pumps, dredging devices, locks and sluices, made way into the European agrarian imagination. Initiatives to drain, reclaim and embank coastal deltas, lowlands and fenlands of Italy, East Anglia and the Netherlands were carried out between the sixteenth and seventeenth centuries. The distinction between 'water and land, between fresh and salt waters, between clear and turbid flows, between individual channels, between lagoon water and river water and between city and terraferma' (D'Souza 2009: 3) was effected/affected as surmised by Venetian hydrologists Nicolo Zen and Cristoforo Sabbadino whose hydrological principles were applied at multiple scales (Cosgrove and Petts 1990). Several European rivers were straightened, dredged, embanked, channelized and shortened, and meanders, swamps, marshes, loops and various other forms of soil–liquid hybrids were obliterated. The introduction of modern hydrology and implementation of drainage and reclamation campaigns saw the great separation between land and water, where '[c]hannelized rivers, calibrated as arteries for trade … principally served as technical arrangements to circulate the economy of land' (D'Souza 2009: 4).

In South Asia, modern hydrology was transplanted into the colonies. Rivers were robbed of their rich cultural contexts, individual histories and unique geographical attributes. All rivers appeared to be the same to the British colonial engineers, the only purpose being huge returns on investments. As the Britishers realized the nature of tropical rivers is different from the temperate ones, aggressive interventions were implemented to tame these unruly rivers and their wild marshes, swamps and wetlands as part of the integrated deltaic systems.[3] South Asia encountered three major stages of 'modern' hydraulic interventions under the British rule: the embankment era with concrete structures constructed to insulate lands from floodwaters; the perennial irrigation epoch with the aim of ensuring a continued supply of river water in the excavated canals for steadily accomplishing agricultural and navigation purposes; and MPRVD, or the building of big dams and barrages on rivers to generate hydropower and control massive floods. Each stage was more technologically aggressive and socially disruptive than the preceding one, and successfully led to the physical and intellectual separation of land and water. Soaked lands and 'muddyscapes' were considered unproductive as these disrupted the colonial 'calculus of rule' based on the 'fixed rent' regime—a significant departure from the precolonial period—'from the levying of tax on the gross produce to rent on the land under colonialism' (Mukherjee and Ghosh 2020: 53). With this economic rationalization, 'floods came to be perceived no more as blessings positively impacting soil fertility and protecting inhabitants from mosquito-borne diseases like malaria, but as a curse' (Mukherjee and Ghosh 2020: 53). The changes in the ecological regime altered social dynamics in deltas, transformed equations among multiple state and local actors, led to the emergence of new classes like intermediaries and also fostered 'constant chasms between different agencies and wings within the colonial bureaucracy and technocracy' (Mukherjee and Ghosh 2020: 55).

Recent postmodern water scholarship has interrogated the land–water binary across alternative and innovative theorizations along themes of hybridity, wetness, rhythmicity and so on. Anthropologists, geographers, historians, political ecologists and social scientists have started exploring sediments as simultaneously physical and social sites of interactions.[4] During the 1980s and 1990s, researchers initiated

[3] That the unusual volatility of fluvial regime of tropical deltaic rivers became a constant source of colonial anxiety is reflected in Hunter's (1875) remark within the context of the lower course of the Mahanadi River:

> In the [pre-deltaic] stage [the river] runs on a lower level than the surrounding country, winding through mountain valleys and skirting the base of the hills. During this long part of the career, it receives innumerable streams and tributaries from the higher country on both banks. So far it answers to our common English idea of a river. But no sooner does it reach the delta then its whole life changes. Instead of running on the lower ground, it gradually finds itself hoisted up until banks form ridges which rise high above the adjacent country. Instead of receiving confluents it shoots forth a hundred distributaries. In short, it enters upon its career as a deltaic river and presents a completely different set of phenomenon from those we are accustomed to in European stream (176).

[4] The notion of 'undisciplined disciplines' implies diverse frameworks that forge and implement bottom-up, unconventional sets of methods and methodologies, often relying upon and borrowing

discussions on the relations between humans and non-humans, objects and subjects, their arrangements and their hybrids (Latour 1991, cited in Lafaye de Micheaux and Kull 2020). These works, along with epistemological contributions, led to ontological ruptures where a world with boundaries of 'what is' were blurred (Braun 2008, Lafaye de Micheaux and Kull 2020). A critical literature dedicated to explore fluidscapes has risen to explore the intersections among water, sediments and societies. Advancing Appadurai and Breckenridge's (2009) theory of hybridity and wetness, Lahiri-Dutt (2014, 2017) interrogates the deeply entrenched land–water dichotomy, addressing the need to interpolate nebulosity in water epistemology. Hybridity enables a rethinking and re-examination of the nature-culture divide that has bedevilled the discipline of geography almost since its inception. Along with hybridity, Lahiri-Dutt extends their wet theory 'to accommodate messiness and contextual variations' and 'to capture the fluidity inherent in the idea of hybridity' (2014: 512, 2017: 53). Liberating mainstream geography and geomorphology from the 'hard edge', Lahiri-Dutt (2017: 53) elucidates how wetness is imbricated with the potential of building upon soft edges, dismantling strong bifurcation in the sciences between land and water formulated against accurate and systematic measurement, assessment, planning and control, and also enabling us 'to rethink lands as spongy and aqueous, and as uncertain and fluid.' Hybridity provides the conceptual and methodological prism 'to relinquish the notion of permanence in land', manifesting 'the constant negotiations between the land and the waters' (Lahiri-Dutt 2017: 53). Wet theory thus empowers social scientists to explore complexities and uncertainties for environments in flux—muddy and silty realities make way into critical geographical discourses beyond concrete categories like land and water.

While Lahiri-Dutt (2014: 507) describes tropical estuarine–deltaic-scapes as 'part land, part water, but is neither in its entirety', Krause (2017a: 1) proposes an 'amphibious anthropology' of delta life, where the 'muddy ambivalences of delta environments' can best be explained in terms of 'not quite firm land and not quite open water, or sometimes one and sometimes the other, with water periodically in excess and repeatedly scarce.' Drawing from the works of philosophers like Sloterdijk and Heinrichs (2001) and Ten Bos (2009) and anthropologists like Gagné and Rasmussen (2016), Krause's method of amphibious anthropology is significant to explicate the limitations ingrained in 'terrestocentric' approach while dealing with delta dynamics. Anthropologists have applied this approach to conduct empirical studies on delta environments; studies on the Mekong Delta by Biggs (2010) and Taylor (2014) demonstrate clashing perceptions between the Vietnamese state and the local people shaping material, political and social lives of the delta. Similarly, by focusing on Thailand's Chao Phraya Delta, Morita (2016) and Morita and Jensen (2017) call for

from each other's disciplines. 'The idea becomes further relevant for "undisciplined environments" where nature is comprehended as beyond disciplined and controlled, where it not only remains a passive victim but acts as an active agent within transformative contexts' (Mukherjee 2020: 31).

distinct 'delta ontologies'—palimpsest or an intermixture of two ontologies: 'terrestrial ontology' (separating land and water) and 'aquatic ontology' (interpenetration of land and water determining traditional occupations and livelihoods).[5]

Krause (2017a) uses four related concepts, hydrosociality, volatility, wetness and rhythms, to study delta lives using the 'amphibious anthropology' approach. It recognizes the significance of the hydrosocial paradigm, emerging out of political ecology of water and focusing on 'how water and society make and remake each other, over space and time' (Linton and Budds, 2014: 175).[6] Within the uncertainties associated with instability and ubiquitous manifestation of water in quotidian delta lives that shape livelihoods, Krause (2017a: 2) introduces 'the pulsating temporality of hydrosocial life' through the notion of 'rhythmicity.' To Krause (2017a), 'rhythmicity' is better posited than hybridity to explain deltaic-scapes by emphasizing on temporalities than the spatial aspects of the land–water nexus. Based upon Lefebvre's (2004) 'rhythmanalysis' and the idea of 'repetition with difference', 'rhythmicity' can be considered as an important conceptual lens to capture shifting temporalities in delta lives in relation to 'both repeating cycles, including those of the tides, the seasons, development projects, and political influences, and non-repetitive transformations, including those of globalisation and climate change' (Krause 2017a: 4). With two ethnographic cases from northern Europe, he validates how the 'inherent rhythmicity' of temporalities like seasonal floods or hydropower-oriented manipulations on water level and experience of people inhabiting 'in-between environments' are intertwined; to him, apart from or beyond spatial hybridity, lived and experienced temporal rhythms 'of increasing and decreasing wetness and fluidity' (Krause 2017a: 1) remains highly significant for cognizing complexities in delta environments.

Lafaye de Micheaux, Mukherjee and Kull (2018: 5) argue that Krause's (2017a) approach to 'rhythmicity', 'rather than to historicity and futurity' undermines long-term perspectives and political dimensions. Combining environmental history with political ecology and applying the framework of hydrosocial cycle to the Lower Ganga Basin, the authors have not only captured complex political–economic imperatives in the making of muddyscapes along long-term historical scales, but have also enriched the hydrosocial cycle and transformed it into the hydro (sediment) social cycle by incorporating sediments in documenting water–society dialectics.

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[5] While terrestrial ontology corresponds to the Western modernist idea of understanding deltas as extension of the sea into the land, in aquatic ontology the delta extends the sea into the land (Krause 2017b).

[6] Rooted with the political ecology of water, which looks into the political and social construction of water, the hydrosocial cycle provides a radical critique to the hydrological cycle, accounting for the material as well as discursive co-production of water and society (Bakker 2000; Linton and Budds 2014; Swyngedouw et al. 2002).

Fluid Tales of South Asia: Rethinking the Stable–Unstable Nexus

The last decade has seen significant advancement in water research with epistemological departures integrating water–society dimensions with just and inclusive hydroscapes. This is manifested in the emerging fields of socio-hydrology and hydrosocial—the former relying upon quantitative or mathematical modelling to represent the water–human relationship and the latter unfurling how power characterizes water–society connections, and how water shapes and is in turn shaped by society. Political ecology of water (Alatout 2012; Bakker 1999; Matthews 2012; Molle 2005; Norman and Bakker 2009; Peterson 2000; Sneddon and Fox 2006; Vogel 2012) and its hydrosocial analysis (Bakker 2000; Boelens 2014; Bouleau 2014; Bourblanc and Blanchon 2014; Budds 2009; Budds and Hinojosa 2012; Fernandez 2014; Hommes et al. 2016; Mollinga 2014; Perreault 2013; Swyngedouw 2007) have been applied to study rivers and river basins. Rivers are being understood as simultaneously material, relational and symbolic. Natural and social scientists are now interested more than ever to perceive rivers and river systems 'as both social and natural' (Wesslink et al. 2017: 2). There is an argument 'for considering the hydrological and the social together: for thinking relationships through water' (Krause and Strang 2016: 633). 'Hydrosociality of flooding' (Krause 2016) and hydro(sediment)social cycle (Lafaye de Micheaux, Mukherjee and Kull 2018) are the latest frameworks to expand the cognitive realms to reimagine rivers.

The mainstream hydrological–epistemological rupture and alternative radical ontologies to understand 'what river is' emerged during the early twenty-first century in South Asian social science scholarship. South Asian water social scientists—especially environmental historians and (social) geographers—brought to the fore the water–society enmeshing as the existential and essential reality. Originally trained in geography, Lahiri-Dutt (2000,2015) has voiced her discomfort in imagining a river as a static physical entity, arguing that rivers are not just lines on maps. Much before the emergence of hydrosocial literature or mesologie and hydro- cultural discourses, Lahiri-Dutt (2000: 2396) had stated that the river is 'neither outside society, nor is it just a thing out there in nature,' asserting how rivers keep interacting with culture. Growing up at a time when dam construction was perceived and propagated as an icon of nationalist accomplishments and developmentalist visions, she had voiced her concern about how Western scientific knowledge abstracted South Asian rivers from their local social and cultural contexts. 'We grew up believing what was taught to us in our school and college textbooks, that all rivers do, and can, flow in a controlled manner' (Lahiri-Dutt 2000: 2396).

Environmental historians, especially water historians, of South Asia have critiqued colonial hydraulics for manipulating, re-ordering and realigning southern and eastern Indian deltas to suit bureaucratic revenue interest motives. Eastern Indian deltas such as the Ganga and Mahanadi are proof of colonial experiments with flood control through the construction of large spurs and embankments (D'Souza 2006; Klingensmith 2007; Mishra 1997, 2008; Singh 2008, 2011). The success of the statecraft was critically dependent on the ability of the colonizers 'to subdue and train the volatility of the delta's hydrology' (D'Souza 2002: 1264). While on the one hand, the colonial engineers missed and ignored the significance of traditional irrigation methods that accommodated 'solids' in rivers, for example, overflow irrigation in Bengal, on the other, modern embankments designed to insulate lands from inundation resulted in the silting up of channels and aggravated floods by raising flood lines to dangerous levels (D'Souza 2006; Klingensmith 2007). Though Lahiri-Dutt (2014) and D'Souza (2009) provoked scholars to look beyond the land–water binary to comprehend the dynamic nature of South Asian deltas, it is only during the present decade that scholars began documenting historical-ethnographic accounts of these fluidscapes. These experiential narratives, capturing lived realities in different chars of South Asia, validate why mainstream notions of stability and fixity do not hold ground in these unstable environments, thereby providing a deeper understanding of the complex stable–unstable nexus and their long-term, large-scale implications across global and local contexts.[7]

In *Dancing with the River*, a seminal work on the microcosmic world of chars in the Damodar Valley in Bengal, Lahiri-Dutt and Samanta (2013) explicate how chars destabilize land–water physical boundaries and administrative borders due to their imperceptibility. The authors trace quotidian experiences of char dwellers, or 'river gypsies', who move with the changing mood and movement of the river. Their every movement is 'informed by the intimate knowledge developed over many years of living in a fluid and dynamic environment' (Lahiri-Dutt and Samanta 2013: 29). Inserting the political into the geomorphology of sediments, researchers explain how these ephemeral-scapes fall prey to 'the art of not being governed', that these 'micro-scale geographical phenomena' call for a 'transdisciplinary epistemology' (Scott 2009: x, xi), combining environmental history, social geography and cultural ecology. The book advances an understanding of sediment not only as an ecological and a geomorphological entity, but also as a social site of interactions bearing crucial marks of 'colonial and postcolonial interventions into the lands and waters of Bengal' (Lahiri-Dutt and Samanta 2013: 7).

The chars need to be contextualized within specific temporal moments—emerged/submerged/re-emerged—as negotiated spaces across an interplay of water, silt and society. They provide a vivid historical–geographical-ethnographic account of the lower Damodar Valley chars with first-hand narrative of different aspects of migration, histories of occupancy, land rights, vulnerability, security and livelihoods. The history of settlement in chars as part of the larger politics of Bengal (1947 Partition and 1971 Bangladesh Liberation Movement) shows how the marginalized, displaced people (or refugees) were encouraged to inhabit these ungovernable and unclaimed lands rising from the riverbed. Chars emerge as emblems to destabilize mainstream ideas of risks and vulnerabilities, inculcating distinct fluid identities and new cultures among the inhabitants.

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[7] Within the context of floodplains and coastal Bangladesh, the vicissitudes caused by structural stereotype 'solutions' like construction of embankments and cross dams on people's livelihoods have been ethnographically explored (see Zaman 1993; Haque and Zaman 1993).

Mukherjee (2011a, 2018, b), Lafaye de Micheaux, Mukherjee and Kull (2018) and Mukherjee and Ghosh (2020) have studied the unrecognized, undocumented and unclaimed chars of Malda and Murshidabad districts of West Bengal. These works have explored drivers and dynamics of change in the chars of the upper stretch of the Lower Ganga Basin (LGB) to capture vulnerabilities and adaptive practices prevalent in these regions. Along with and apart from ethnography, Mukherjee (2011a, b) and Lafaye de Micheaux, Mukherjee and Kull (2018) employ historical research methodology to learn the changing patterns of char formation in this region since the operation of the Farakka Barrage Project.[8] Mukherjee concludes that though char formation is a natural occurrence in the LGB, the implementation of the Farakka Barrage Project has impacted patterns of riverine erosion and sedimentation with repercussions on the formation, consolidation and dissolution of chars. The upstream (Malda) and downstream (Murshidabad) of the barrage is dotted with temporary chars—the constant emergence and submergence phenomena has forged repetitive cycles of the SDRR syndrome among the char dwellers (Mukherjee 2011b). Numerous challenges in these chars, including aversion of the statecraft to recognize these areas as governable, emanate from the SDRR. While communities in chars depend on ecosystem services and adapt to environmental and social vulnerabilities, Mukherjee (2011b) argues that coping strategies in chars should not be romanticized. Apart from empirical description, the scholarship on the upper stretch of the LGB is also pathbreaking in terms of enriching the hydrosocial cycle and transforming it into the hydro (sediment) social cycle, reflecting on shifting social meanings of sediments across transforming colonial and contemporary trajectories (Lafaye de Micheaux, Mukherjee and Kull 2018).

Exploring the 'immense archipelago of islands' in the lower stretch of the LGB, that is, the (Indian) Sundarbans Delta, Lahiri-Dutt (2014: 516) argues that here 'neither do rivers flow along a certain route, nor is the land fixed and permanent.' During precolonial times, traditional agricultural, irrigation and fishing practices were aligned with the attributes of the floodplain. These cultural practices, based upon intergenerational transmission of indigenous knowledge, encountered fundamental transformation with the 'modern' separation between land and water. Employing the legal history perspective and analyzing two major acts of colonial Bengal—the Permanent Settlement Act of 1793 and the Bengal Alluvion and Diluvion Regulation Act (BADA) of 1825—Lahiri-Dutt (2014: 521) shows how 'an absolute boundary between the land and the rivers' was crafted that 'altered the meanings that these elements of nature held to local residents.' Huge concrete embankments insulated water from lands and accumulating silt on the riverbanks, giving birth to chars.[9] To optimize on profits, the British, through the passage of BADA, formulated rules to

[8] The Farakka Barrage was constructed in Murshidabad district of West Bengal to improve the deteriorating course of the Bhagirathi–Hooghly River and hence revitalize the Kolkata Port through the construction of 109 lock gates. The project was initiated in the early 1960s and was completed in 1975.

[9] The Permanent Settlement was introduced by Lord Cornwallis in 1793. It was an agreement between the British East India Company and the Landlords of the Bengal Province (Bengal, Bihar and Orissa) to settle the Land Revenue to be raised.

establish claims on lands emerging out of accretion and erosion. Against payment of fixed and continuous rents, the state ensured the ownership rights of the person/family on re-alluviated land.

While case studies on chars in the Ganges trace disruptions led by colonial hydrology and focus on the nuances of everyday lived realities destabilizing mainstream notions of vulnerabilities and risks, explorations on chars of the Brahmaputra Valley in Assam are loaded with political ecological narratives surrounding migration of people from chars, marginalization, exclusion and identity crisis, often culminating in violence and bloodshed (Chakraborty 2010, 2011, 2012, 2013; see also Goswami 2014). Consulting historical records and census data, Chakraborty (2012: 23) narrates how these chars were converted into human habitation under colonial initiative when people from then East Bengal were brought in to pursue agrarian activities facilitating revenue generation. Devastating floods and high erosion rate in the Brahmaputra Valley since the Independence has compelled char people to migrate to mainland Assam where 'they become the victims of suspicion.'[10]

More recent works on the Brahmaputra, especially its largest char, Majuli, has been conducted by Baruah and Mukherjee (2018) who have applied the lens of environmental history and social anthropology.[11] It clarifies how chars should be analyzed as heterogeneous entities—size, duration, etc.—playing crucial roles in determining vulnerability and resilience among the inhabitants. Drawing from Linton and Budds (2014) nand Krause (2017b), the authors argue that 'as part of the hydrological processes in the valley, annual floods have found their place within the hydrosocial cycle, thereby producing "rhythms" against which the Assamese society has organised its economic and cultural activities' (Baruah and Mukherjee 2018: 329). Recent times have seen an increased displacement, loss of land and livelihoods and a steady flow of outmigration due to massive techno-engineering interventions under the colonial regime, later accelerated by the postcolonial state (Saikia). Embankments along with a range of other infrastructures such as boulder spurs, geo-textile bags and mattresses, small and large dams, etc., to control floods in the valley have in fact aggravated it. Baruah and Mukherjee capture shifting temporal and cultural dynamics demonstrating that processes.

> ... that were defining characteristics of the island for generations (for instance, monsoonal flooding and sedimentation of the river and wetlands in and around the Majuli terrain) have now turned disastrous, rupturing the 'rhythm' in the hydrosocial metabolism, thereby turning Majuli into a 'hazardscape' (2018: 330).

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[10] Goswami (2014) explains how chars of Assam remained geographically alienated from the mainland and psychologically detached from the mainland population. Providing a comprehensive coverage of 1000 char households spanning over four development blocks in two districts of Barpeta and Kamrup, Goswami captures micro-details of demographic and occupational aspects shaping livelihoods and well-being of char communities.

[11] Majuli River Island is the largest in the world. It comprises about three dozen cluster of islands, locally called *chaporis*, 'all of which are lived-in geographies, centering on a large contiguous landmass, which is interestingly referred to as the mainland by the chapori-dwellers' (Baruah and Mukherjee 2018: 327).

Embankments have forged a distinct spatiality of vulnerability within the island by protecting the 'inside' long stretch of Majuli landmass against costs of exposure to massive floods for the smaller 'outside' chars encircling the island. However, the notion of safety even in the inner zone gets destabilized with the fact that unpredictable embankment breaching causes catastrophic flooding, upsetting agricultural productivity as floodwaters do not revitalize the soil with accumulated alluvium during the post-embankment scenario anymore. A series of dams on the Brahmaputra have turned Majuli into a victim of infrastructure-induced disasters, turning chouras into a homeless population, triggering occupational and identity crises as well as outmigration. Baruah and Mukherjee (2018) also discuss adaptive practices pursued by ethnic communities like the Misings and the Kaivartas as a way to reimagine the fate of the chars during the Anthropocene.

Basu et al.'s (2018) volume is a narrative of those inhabiting the river banks of Bihar, deltaic Bengal and the Brahmaputra and Barak Valleys of North-East India, negotiating nature, on the one hand, and the economy, politics and administration, on the other. While sections from the volume highlight how the marginalized char dwellers face challenges worsened by governmental policies, conversely, in their studies, Lafaye de Micheaux, Mukherjee and Kull (2018) and Mukherjee and Ghosh (2020) showcase stories of survival, where the inhabitants have benefited from welfare schemes and programmes of the national and state governments. These positive tales entail only a fragment of the larger char story. Yet, these ensure the prevalence of multiple epistemologies comprising stories of victories and violations that need to be heard and documented.

Conclusion

Environmental historians and human geographers of South Asia have established why and how chars destabilize the sacrosanct categorizations of land and water by applying critical interdisciplinary frameworks like hybridity, wetness, hydro sociality and so on. These transient spaces and hybrid deltaic environments await rigorous empirical explorations with potential to destabilize mainstream notions of risk and resilience in the Anthropocene. If the 'plural' can be elicited along with the 'political' to capture the wide spectrum from conflict to collaboration among multiple actors in the political ecological frame of analysis (Mukherjee 2020) to explore char dynamics, the numerous worldviews and array of practices in heterogeneous chars of South Asia can be recognized along discrete temporal and political-economic frames.

The islanders inhabiting dynamic transition zones are exposed to edge effects, marked by challenges and tensions, which makes them exceptionally adaptive (Hay 2013). Thus, risks shape resilience in these otherwise volatile environments. However, though this line of argument is risky in terms of providing fodder to the statist legitimization of non-intervention in chars, which are ecologically and economically self-sufficient, this frame of analysis, validated with rich empirical datasets across different chars of South Asia, can destabilize our own understanding of chars from emblems of uncertainties, volatilities, risks and vulnerabilities to ‘zones of interaction … transformation, transgression and possibility’ (Howitt 2001: 240).

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Chapter 4
Dynamic Land and Adaptive People of Bengal Basin and Its Charland

C. Emdad Haque and Mohammad Jakariya

Abstract This chapter presents an analysis of the dynamic geophysical character and human ecological system as found in the Bengal Basin. Characteristics of the Bengal deltaic geophysical and hydrological systems are briefly discussed, followed by a discussion on adaptive response of the inhabitants in view of the dynamic shifts of river channels in the delta building process. The analysis reveals how people living in the delta and the floodplains adapted to the historically unstable and dynamic shifts of the river channels; and thereby made their living and sustained their livelihood. This is further illustrated by case study evidences from the Brahmaputra–Jamuna and Ganges/Padma floodplains, dealing with contemporary coping strategies and adaptive behavior of floodplain residents toward risk management. This adaptive approach to displacement, migration and resettlement needs to be properly understood in formulating and implementing an effective char development policy in Bangladesh.

Keywords Bengal river basin · Dynamics of erosion and accretion · Adaptive responses · Resettlement · Charland management and policy

Introduction and Objectives

The Bengal Basin, encompassing the lower floodplain and the delta deposits of West Bengal (India) and Bangladesh at the mouth of the Ganges–Brahmaputra–Meghna (GBM) river system, is one of the most extensive sediment reservoirs in the world. The GBM system together carries over two billion tonnes of sediment annually to the Lower Meghna estuary and the Bay of Bengal located to the south (see Chaps. 8 and 9). As a result, the floodplain and the delta historically experienced dynamic river

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channel systems in the process of delta formation, creating and recreating the most complex braided and meandering river systems in Bangladesh. Shifting channels, along with sand bars, chars, bank slumping, are all parts of the dynamic deltaic process that continues to date.

Changes in the river systems have influenced the evolution of human settlement and population movement in the Bengal delta (see Chap. 2). In this chapter, we theorize that an understanding of the broader deltaic process—for instance, the delta formation mechanism and river dynamics—is necessary in studying the ever changing charland settlements and human adjustments to the overall floodplain dynamics. First, we examine the characteristics of the Bengal deltaic geophysical and hydrological systems. Second, we discuss the legal framework for the use and access to the new alluvial lands as a form of adaptation to the changing riverine dynamics and the political ecology of charland administration. Finally, we present evidences from the Brahmaputra–Jamuna and Ganges/Padma floodplains on coping strategies and adaptation to charland displacement in contemporary contexts. This adaptation to displacement, migration and resettlement must be understood and integrated in any future policy development for the chars and deltaic plains.

Bengal Delta, Char Formation, and Human Occupancy

Understanding char formation and deformation requires an analysis of the dynamics of delta formation, the river channel patterns and their shifting within which char land dynamics are embedded. This section briefly presents the geomorphologically dynamic and fluid nature of the Bengal Basin's delta and riverine plains and its associated features, such as formation of charlands (see also Chaps. 8 and 9). The dynamic tectonic and fluvial morphological aspects of Bengal Delta and the GBM riverine systems are highlighted, which is followed by a discussion on the variation in char formation among the various geophysical regions of the Basin, and then by a historical account of human occupancy and charland management.

Bengal Delta Formation

The Bengal Basin is located at the junction of the greater Indian, Burma and Tibetan (Eurasian) plates, with an area of about 200,000 km^2 (Fig. 4.1). Approximately a quarter of this area is occupied by the present-day territory of Bangladesh. The Bengal Basin has a more than 20 km^2 of Tertiary-Holocene sedimentary fill, primarily from the orogenic sediments carried down from the eastern Himalayas to the north and the Indo-Burman Ranges to the east (Fig. 4.1; Alam and Curray 2003). Based on stratigraphy and development, recent research has revealed that two factors, namely tectonics and sediment supply, control the GBM system more profoundly than in many other comparable delta systems. As Goodbred et al. (2003) explained, in the

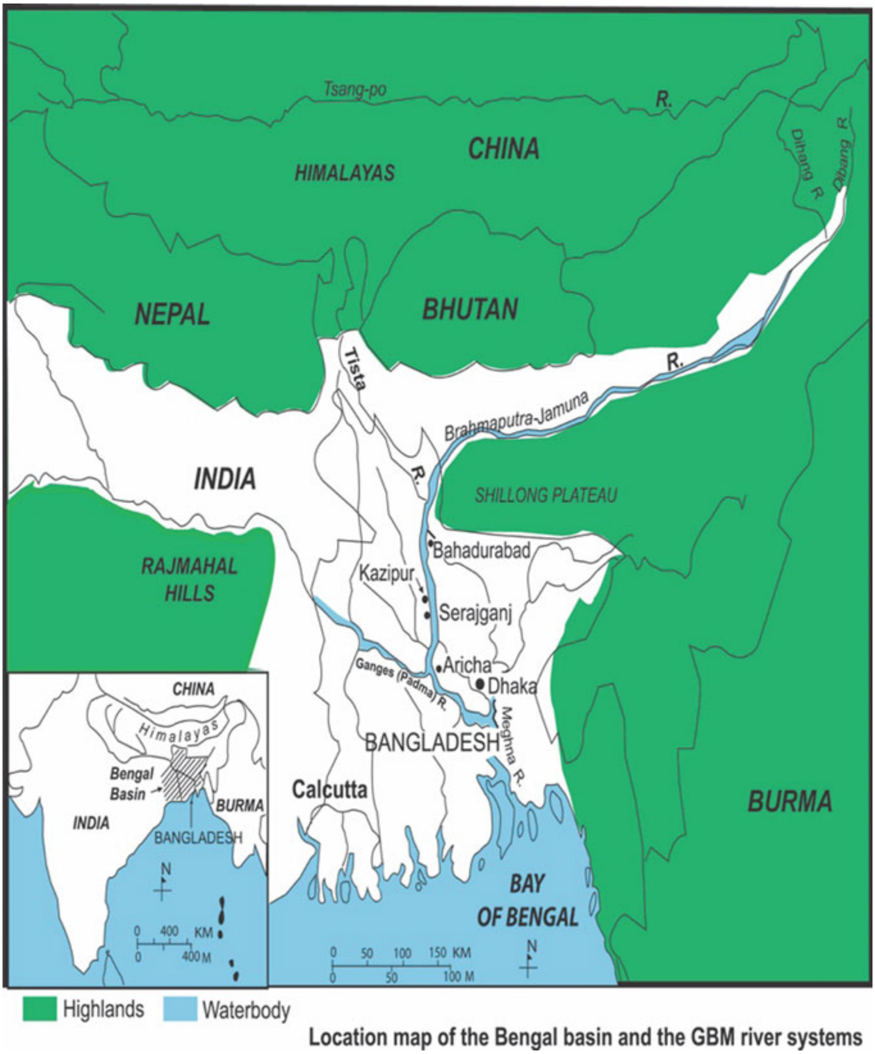

Fig. 4.1 Bengal basin and the GBM river system. *Source* (Haque 1997)

Ganges–Brahmaputra deltaic system, tectonics play an important continental control by active tectonics (i.e., plate-driven vs. passive sedimentary tectonics) by deforming deltaic basin and influencing the volume and distribution of sediments.

Although from an anthropological standpoint a discussion on charland formation on a geological time scale may not seem very relevant, from a geographical and interdisciplinary planning perspectives, some important features relating to current tectonic and fluvial sedimentary processes deserve attention. These are pertinent to contemporary human settlement and and infrastructure building. An example of a recent tectonic event that has had profound impact on the middle and lower reaches of the Brahmaputra River was the 1950 earthquake (Richter mag. 8.7) in the state of Assam, India. This earthquake event significantly affected the course and morphology of a number of Brahmaputra tributaries.

The 1950 Assam earthquake resulted in the introduction of a large unquantified volume of sediment through slope failures (Poddar 1952). This in turn caused an increase in sediment load for several years after the event at the mouth of the Ganges-Brahmaputra rivers, forming chars in Noakhali, Bangladesh (Brammer 1996). Within the Bangladesh territory, faulting, earthquakes, and other tectonic activities also had significant impact on the delta system, affecting controls on river courses, avulsion, and sediment dispersal. The 1782 earthquakes in the Sylhet region caused vertical displacement (near Mymensingh, Bangladesh) that assisted avulsion of the Brahmaputra River from its old course east of the Madhupur Terrace to its present Brahmaputra–Jamuna channel (Fergusson 1863; Haque 1997).

Dynamic Riverine Systems

To understand the dynamic nature of the deltaic land, we need to look at the geomorphic setting, patterns of river channel migration historically, and the process of accretion and erosions. The Ganges River, on rounding the Rajmahal Hills, enters Bangladesh from India at the western end of Rajshahi district and then flows in an east-southeastwardly until it meets at the confluence of Brahmaputra–Jamuna River near Aricha (Fig. 4.2/2b (2)). From the point of confluence with the Brahmaputra–Jamuna River to the confluence with the Meghna River near Chandpur, the reaches are known as Padma. The delta of the Ganges is divided into three zones (Spate 1954): the moribund, mature and active delta. The moribund and mature delta zones, occupying the northwestern, north-central most areas covering Kushtia, Jessore, Faridpur and northern Khulna districts (Rashid 1977). The moribund and mature delta formation over the last three hundred years is described in details by Ahmad (1968) and Akter et al. (2016), revealing that the eastward shift of the main channel of the Ganges has been the primary force in influencing the morphology of these parts of the delta (Fig. 4.2/2a (1); 2a (2) and 2b (1)). In the late eighteenth century, the Ganges and combined flows of the Old Brahmaputra and Meghna were functioning in two separate estuaries for building the delta (Sarker et al. 2014; Fig. 4.2/2b (1)). The Ganges estuary was located close to the northern upstream reach of the Tetulia channel (Rannell's map based on surveys during 1764–1776; Fig. 4.2/2b (1)). However, by 1830, following joining Brahmaputra–Jamuna, the active delta building estuary shifted towards the east (revealed in Fig. 4.2 2b (1) and 2b (2)—comparing Rennell's map and the recent map), resulting in the creation of both moribund and mature parts of the delta to the northwest and west.

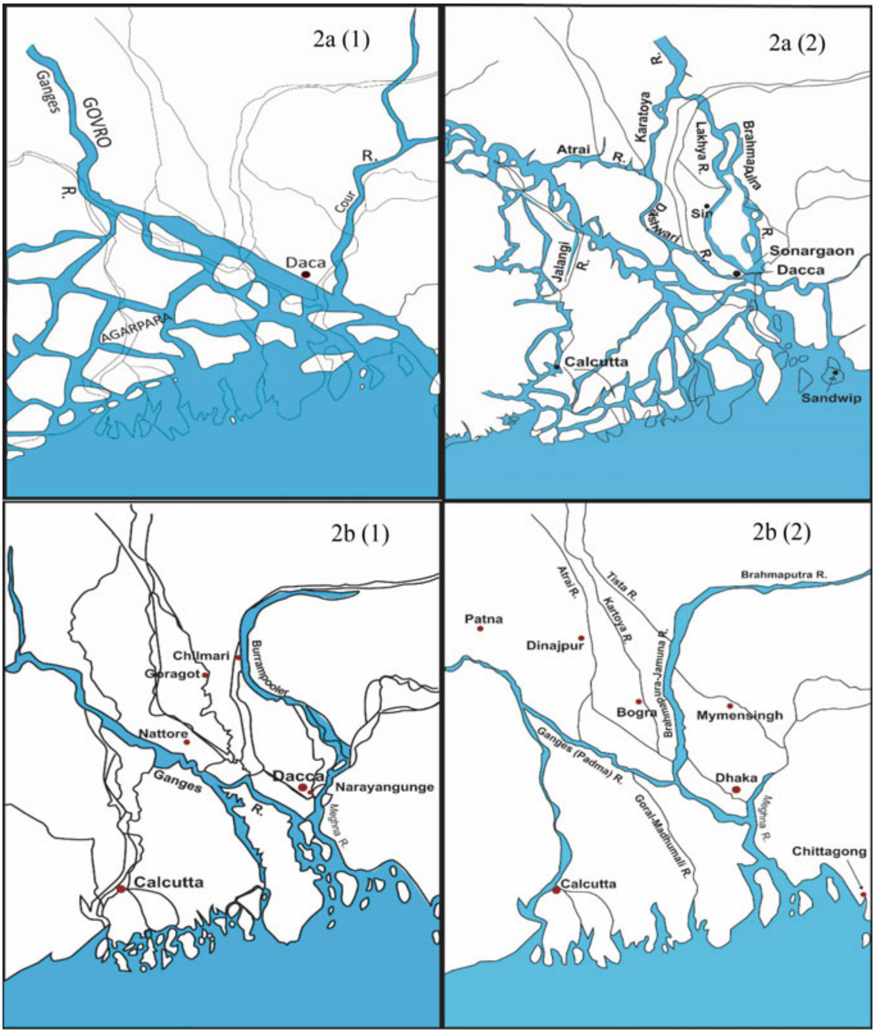

Fig. 4.2 Comparative maps of the Bengal deltaformations. *Source* (Haque 1997)

River Channel Patterns and Charland Formation

The slope, discharge and bed material size determine the river channel pattern characteristics, which are classified into straight, meandering and braided (Leopold and Wolman 1957; Achers and Charlton 1970). As per the bird's eye view of the configuration of a river, several geomorphologists have labelled both the Ganges and Brahmaputra-Jamuna river channel patterns as braided since they are divided into several channels by chars, bars or islands, and these divided channels subsequently join and re-divide (Morgan and McIntire 1959; Rahman 1984). Knighton (1984) notes that the braided rivers are characterized by the abundance of bed load, easily erodible banks, highly variable discharge and steep slopes, with seasonally unstable mid-channel islands/char land.

In the active delta zone, which covers most of Bangladesh's coastal plains, the large islands (such as Ramgati, Hatiya, Bhola, Sandwip) have been formed over the last few centuries, which can be depicted well from the maps of Jao de Barros (1550 AD) and van Den Broucke (1660 AD) (Fig. 4.2: 1a (1) and 1a (2)). The dynamism of the deltaic plain has made its landform ever-changing, and thus quite unstable with varying temporal regime. Most of the land is subject to annual inundation during monsoon, and new land accretion from sediment deposit is an important feature of deltaic processes, particularly in the Meghna-Tetulia-Shahbazpur distributary system (Ahmad 1968; Haque 1997).

In explaining the dynamic and complex nature of these estuarine chars, Brammer (2004) suggests that there are significant differences among the 'old land' on the older islands and new char land such as Bhasan char (see Chap. 10). The age of the old chars is likely to be several centuries, and have developed soils and fresh groundwater. In contrast, the newly accreted chars are characterized by salinity and have undeveloped soils that are poorly suited for agriculture or settlement. The unstable nature of land and settlement is further clarified by Brammer (2004), stating that although there is an average annual deposition of 45 km^2 of new char land in the Meghna estuary (lower Meghna floodplains and coastal plains), there is an annual loss of 25 km^2 land by erosion, mainly on settled land areas. Thus, despite a net gain of 20 km^2 of land in the estuary every year, there is actually a substantial loss of land suitable for agriculture and settlement.

In early nineteenth century, the planform of the Brahmaputra–Jamuna River was meandering in nature. However, with channel widening a continuous geomorphic process, it got transformed into a braided river by 1830 AD (Fig. 4.2: 2b (2)). As the present-day Brahmaputra–Jamuna River enters into Bangladesh, the reaches are strongly braided, the multiple channels of the river system constantly shift via eroding the chars and adjoining riverbanks. They simultaneously deposit alluvium and are engaged in forming accreted land. These new alluvial land within or at the channel sides are locally known as chars. As Sarker et al. (2003) and Brammer (2004) noted, due to their constant erosion and accretion, Brahmaputra–Jamuna char land creates a very dynamic and unstable environment. Charlands start forming as sandy shoals within and alongside a channel, which are usually linear or close to elliptical in shape (Brammer 2004). This results in diverting the channel flow against the opposite bank of the channel, undercutting and eroding it continuously. Along the Brahmaputra–Jamuna River, lateral erosion rates usually are less than 200 m per annum; however, at any local reach, the rate could be up to 1 km in one single year.

Charland Temporal Cycles

The dynamics of chars relating to morphological behaviour of rivers are elaborately explained by Sarker et al. (2003) and Brammer (2004). It is apparent that human settlements on the char land have been determined primarily by two factors: (i) the age of char land, and (ii) the legislative and legal status of both eroded and accreted land. As explained above, within the Meghna estuarine regions, some of the old chars were part of mainland prior to Major James Rennell's survey in the late eighteenth century as he showed that one could travel from Vikrampur area to Dhakshin Shahbazpur, which is present day Hatiya, without crossing any major river. Without any specific settlement record, we can interpolate that some of the large-old islands were settled even during the Mughal period. In the active delta zones of the estuary, however, the chars are of recent origin. The ground water quality is an excellent indicator—whether saline or fresh—to provide clues to suitability to permanent settlement option or other temporary economic activities.

In the context of Brahmaputra–Jamuna and Ganges-Padma Rivers, as Sarker et al. (2003) suggested, it is important to make a distinction between island chars that are usually surrounded by water year-round and the attached chars that become connected with mainland under normal flow conditions. Also, abandonment of any outflank channel can transform an island char into an attached char. An examination of the dynamics of chars using satellite imagery along the major rivers of Bangladesh by ISPAN (1995) revealed that the Ganges–Padma and Lower Meghna are wandering rivers (meandering and braided), the chars there being more stable than the chars in Brahmaputra–Jamuna River system (Table 4.1). In Brahmaputra–Jamuna River, the chars are very young: approximately 68% were less than 6 years old, and only 60% of the chars 'persisted' for 1–6 years. The percentage of chars that persisted more

Table 4.1 Areas of water, sand and chars, 1984–1993

Item	Year	Brahmaputra–Jamuna	Ganges	Lower Meghna
Total water area (ha)	1984	55,740	28,620	45610[b]
	1993	61240[a]	28,980	57,680[b]
Total sand area	1984	54,010	36,230	–
	1993	70,240[a]	35,660	–
Total vegetated land (chars) (ha)	1984	89,580	24,350	11,070
	1993	98,760[a]	35,560	18,070
Total area within the banks	1984	199,330	89,200	56,680
	1993	230,240	100,200	75,750
Ratio of attached char area and island char area	1993	1.00	1.56	All are island chars

Sources Sarker et al. (2003: 67), ISPAN (1995)
[a] 1992 data
[b] Area of water and sand

than 27 years accounted for only 2.2% of the total char areas within-bank in 2000. The Meghna has multiple streams flowing in parallel channels, each of which can behave as a single meandering river. This results in the chars in the Upper Meghna to be quite stable; most of them are island chars that exited for more than 70 years.

Among numerous recent research on the temporal cycles of chars in the large estuaries of Bangladesh, the MES II (2001), and CEGIS (2010) studies highlighted that the accretion and erosion of chars in the Meghna estuary along the southern coastal regions will remain unstable and dynamic in the foreseeable future. These studies explained that while the Mississippi Delta of the USA is characterized by the river-dominated forms (such as bird-foot planform) in terms of energy, the Meghna estuary in contrast is characterized by high tidal energy. High sediment inputs from upstream and high tidal energy from downstream keep the estuary dynamic and the newly formed chars unstable. As a result, "the estuary has been characterized by several thousand square kilometers of land erosion (and)accretion every year" (Akter et al. 2016: 1219). Therefore, the emerging chars downstream of the Meghna estuary are expected to remain subject to high tidal energy-related instability.

Evolution of Alluvion and Diluvion Land Regulations

Over the history, human occupancy and settlement in the floodplains and charlands of Bengal have not only been related to geophysical and ecological factors, but also to the land tenure and legal systems that profoundly affected the social relations and entitlement to resources. Bengal's sociopolitical spheres had undergone considerable changes with the dramatic and large-scale alternations in river systems during the eighteenth century. The process of change commenced with the conquest of Bengal by the British East India Company in 1757. The Company recognized Hindu *zamindars* (landlords), among the various classes of claimants for the settlement of land revenue, as the most eligible agents, and were given tenure along with authority to collect revenue and taxes (Guha 1963; Stokes 1978). With an assumption that permanent tenure and fixed assessment would inspire individuals to reclaim vast areas of potentially cultivable wasteland, including charlands, the Company made agreements with the *zamindars*, along with independent *talukdars*, and the "actual proprietors" of the land. By a proclamation in 1793, this action, known as the Permanent Settlement Act, was implemented all over Bengal.

The role of the state (the British Raj) in administering areas of Bengal became distinctive in 1825, when the Bengal Alluvion and Diluvion Regulation was implemented. Claims to ownership of alluvion and diluvion land were regulated by local customs and title prior to the enactment of this legislation (Zaman 1987). The 1825 Regulation offered that in the case of clearly recognizable and established matters, claims and disputes over alluvion land be decided upon by considering local use of *payasti* (alluvion) and *sikosty* (diluvion; Gupta 1940; Ali 1980; Haque 1987). This Regulation was clearly enacted to protect the mutual interests of *zamindar* and big landlords—a product of an alliance between these predominant groups during the British colonial period. As a result, land gained by the gradual accretion from receding rivers was annexed to the tenure of the person whose estate it adjoined (Ali 1980), but a submerged estate that subsequently became attached to an adjoining estate would not fall under the legal control of the latter upon re-emergence. The established owners prevailed in such matters.

Following the Partition of Indian sub-continent in 1947 and the abolition of the *zamindari* system, the Act of 1950—known as the East Bengal State Acquisition and Tenancy Act (EBSATA) was enacted. It enforced two constraints on the restoration to the previous owners of lands lost by diluvion: (i) the restoration was legal if it occurred within 20 years following the event of diluvion; and (ii) such restoration was legal only if the possession of the land area remained in the hands of rent receivers or cultivating *raiyat* (Sect. 20 of the EBSTA, 1950) and satisfied the constraint of transfer of holdings up to a maximum of 50 hectares (125 acres; Sect. 90 of the EBSATA, 1950). The Act emphasized the de facto possession of the land, and reflected the emergence of Muslim landlords as the main sociopolitical and economic power in the riparian areas of Bengal, replacing the absentee Hindu *zamindars.*

Post-independence (1971) Land Reforms

In Bengal, a process of social differentiation began as early as in the late Mughal period (Abdullah 1980). The patterns of revenue-demand from the peasants began to undermine the traditional ties that had been established by the Hindu caste system over the centuries. The proportion of marginal cultivators and landless has been steadily increasing and new social relations evolved around land-based power dynamics. Consequently, an unequal power structure gradually emerged in rural Bengal, controlling land within a "patron-client" or "headman-subordinated follower" framework; such unequal power-structure was more profound in charlands than in other parts of Bengal's deltaic floodplains (Zaman 1991).

In view of the increasing landlessness of the rural masses, the post-Independence (1971) government of Bangladesh introduced new policies to recover all alluvion lands from the control of *jotedars* (large landlords), and to redistribute them among the landless and peasant smallholders (who owned less than one-seventh of a hectare of land). With the objectives of encouraging cooperatives, collective settlement and farming, the Presidential Orders of 1972 (numbers 72, 35 and 135) enacted that all newly emergent lands previously lost by diluvion should be restored to the government (as public land) and not to the original owners (Malik 1983). Subsequently, it was proclaimed that all char lands, irrespective of whether reformation in situ or new accretion, are to be considered as public (*khas*) land.

In 1975, following a military takeover of government, the democratic legislative system of the country was abrogated. In conjunction with such abrupt political changes, the political forces supporting large landlords regained, although for a short period of time, their power and rights at the local level (Haque 1987). In the Ordinance 61 of 1975, which established that the owner of land lost by diluvion is the 'first' person eligible for settlement, recognizing the right to repossess the re-emerged land. This was summed up clearly by one commentator—"what has been taken away with one had has been given back with another" (Malik 1983: 27).

In 1994, the Presidential Order No. 135 of 1972 was further modified with the Amending Act of XV of 1994 with the provision for abatement of rent lost by diluvion and subsistence of the right to land re-formed in situ for 30 years (discussed in greater details in Chap. 24). However, it is important to note here that many laws, largely derived from the colonial period, determine charland ownership, use and management in contemporary Bangladesh. For instance, the Agricultural Khas Land and Settlement Policy (1997) was formulated to distribute *khas* land to the landless on a 99-year lease arrangement (Masum 2017). A recent study (Tariquzzaman and Rana 2014) noted that the process of acquiring *khas* land has been more a political rather than legal process, benefitting the powerful elites in their localities. As considerable portion of *khas* land has been illegally occupied and "owned" by such elites, the government did not have even ownership and control over such public lands. Such land grabbing is more acute in the charland areas throughout the country (Feldman and Geisler 2011).

Coping with and Adaptation to Charlands

A number of empirical studies on coping with and adaptation by the char people to environmental risks associated with floods and riverbank erosion have revealed that people have historically developed certain distinct coping and adaptation behaviour (Hutton and Haque 2003; Zaman 1989, 1991; Haque 1997; Islam et al. 2014; Islam 2010). Decades of experiential and social learnings by the local communities demonstrate their enhanced coping ability (i.e., immediate and direct response to the impact of an extreme event) and adaptive capacity (i.e., long-term strategies enabling change and transformation to deal with adverse effects; see Welle and Birkmann 2015). This section provides further evidences from Kazipur in the Brahmaputra–Jamuna and Shibchar in the Ganges/Padma floodplains highlighting the indigenous coping strategies and adjustments.

Kazipur in the Jamuna–Brahmaputra Floodplain

An international collaborative research project, namely the Riverbank Erosion Impact Study/REIS Project (1983–1988) investigated the river channel migration and resultant population displacement in Bangladesh (see Zaman and Haque 1991; Elahi et al. 1991). The field studies of the REIS Project were carried out in three Upazilas of the country: Kazipur and Chilmari of the Brahmaputra–Jamuna floodplain and Bhola of the Meghna Delta Plain. Haque (1997) re-visited Kazipur Upazila some 10 years later in 1993–94 to understand changes in bank erosions and responses. The results of the re-study are summarized below.

Kazipur, located on the right bank of Brahmaputra–Jamuna river, has many chars across the main western channel. In 1997, during the revisit, Haque (1997) listed numerous coping and adaptation measures among char dwellers for dealing with charland erosion and slumping hazards. It was observed that the char inhabitants purposefully use easily dismountable and moveable materials such as thatch, bamboo, wood, and corrugated iron sheeting in constructing their dwellings, instead of using brick, steel, concrete and other quality (*pucca*) housing materials. More than 77% of the respondents ($n = 247$) used corrugated iron sheet as their roof materials; others used thatch, bamboo, and other locally available materials. Because houses made of these materials are readily moveable in emergencies, they are less susceptible to loss by floods and soil or bank erosion than are permanent masonry structures.

Agricultural coping strategies are also geared to reduce potential flood and bank erosion losses by the char dwellers (also see Paul 1984; Rasid and Paul 1987). With relatively lower relief than the mainland areas, the char land soils along the Jamuna–Brahmaputra River are usually composed of calcareous loams (Rashid 1977). As these porous sandy soils (i.e., *bali*) do not suit *boro* paddy, but work well for pulses and other winter crops, farmers in the char land follow a clearly distinct cropping pattern than in the mainland (Table 4.2). As shown in Table 4.2, most households in Kazipur chars cultivate more *aus* and *aman* paddies compared to the mainland. The chars also seem to be more suited to the cultivation of pulses than other winter crops. The significant variations are reflected in the chi-square estimate of homogeneity between the Char Land Zone and the Main Land Zone—which is 148.4 ($p < 0.001$ level).

An analysis of the cropping patterns in various zones reveal that people living in hazardous areas like the charlands, tend to reduce the magnitude of their potential crop loss from environmental hazards by cultivating least-cost varieties. For example, among all the crops, *boro* paddy and potatoes involve relatively higher investment

Table 4.2 Percentage distribution of cropping patterns by zone in Kazipur (Multiple responses possible)

Type of crop	Charland zone ($n =$ 247)	Main land zone ($n =$ 73)
Aus (paddy)	93.0	35.5
Aman (paddy)	76.6	90.3
Boro (paddy)	15.1	80.6
Cane	1.2	–
Potato	23.3	48.4
Pulses	60.5	25.8
Oilseeds	34.4	67.7
Spices	58.7	64.5

Source Kazipur Survey 1993–1994; X^2 ($p < 0.001$; d$f = 7$) = 148.4 (Significant) costs and intensive care in terms of water supply and management. Percentages of farm households cultivating these two crops are significantly lower in the Charland Zones than in the Main Land Zones in Kazipur.

Shibchar in the Ganges–Padma Floodplain

In a recent empirical investigation in the Char Janajat, a large mid-channel island char located in Ganges/Padma floodplain, Islam (2010) depicted the intertwined relationships between floods and riverbank erosion and slumping. In 2003, the population size in Char Janajat Union was 13,958 in an area of 84.1 km^2. Floods here inundate not only settlements, but also standing crops and infrastructure. During the period of flood recession, large-scale riverbank slumping and land loss take place in these riparian areas, causing devastating adverse impacts on char livelihoods—adversely affecting the settlements, standing crops, livestock, and other capital-assets such as infrastructure and road network.

In Char-Janajat, displacement of families due to land loss by floods, and bank erosion and slumping is common. Islam (2010) estimated that on average approximately 971 inhabitants have been displaced only in one *mouza* (revenue village) annually by the loss of household land. Among the displaced families, approximately one-third (28.7%) preferred to stay in the area, with a coping behaviour of recurrent movements (Fig. 4.3). Similar to Haque's (1997) study in Kazipur, a significant proportion of displaced people here in the Ganges–Padma floodplain and char-systems tend to move only a short distance with the hope to eventually moving to a newly accreted land.

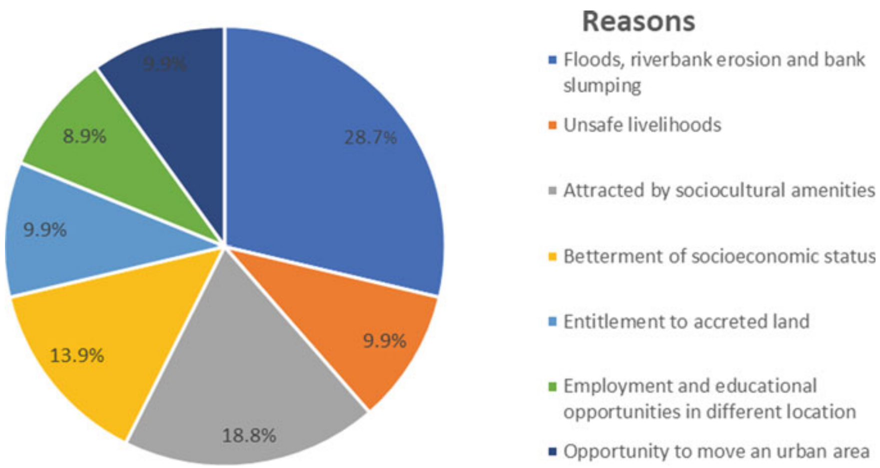

Fig. 4.3 Causes of displacement (%) in char Jananat Union. *Source* Data adapted from Islam (2010)

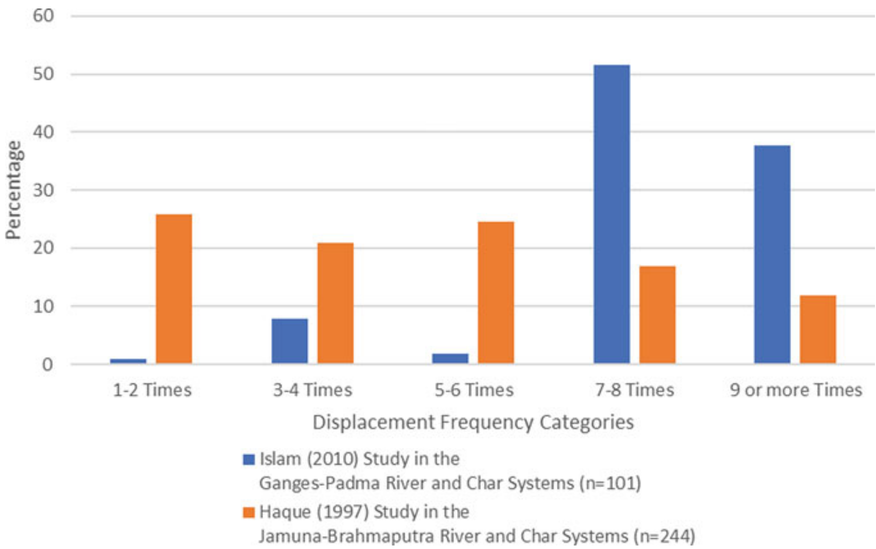

Fig. 4.4 Comparison of displacement frequency (%) in Shibchar and Kazipur chars

Majority of the displaced families experienced more than seven displacements in their lifetime in Char Janajat in Shibchar (Fig. 4.4). The coping and adaptation behavior of the respondents in the char land areas overall reflect a high degree of experiential learning and motive to regain the lost land and socioeconomic status. In this regards, it appears that displaced persons chose to remain close to their place of origin to minimize their socio-economic and cultural stresses, a pattern commonly found among people in disasters (see Wallace 1957; Oliver-Smith 1982). The continuity of local support and sociocultural identity is of vital concern to such disaster victims. Zaman (1987), who carried out anthropological study of char villages in Kazipur under the REIS Project, observed that the 'cultural-psychological' explanation is not enough to understand to understand post-displacement settlement; short-distance migration (i.e., staying around the place of origin) by displaced families has underlying socio-economic factors. Thus, Zaman (1987: 17) rightly argues that "it is not conservatism but the hope to regain access to depositional land that remains a key factor in the migration decision." In sum, the displaced families who do not have their own land to resettle, or who cannot expect any material support from their poor relatives or other local institutions, have their choices limited either to move as squatter settlers on the flood embankment illegally, or remain in the char areas as 'dependent' on powerful land owner—not only for land and other immediate support for resettlement, but also for employment, be it as low-paid labourers.

Conclusion

The chapter demonstrates the historical dynamics of land formations and changes in landscapes and settlement patterns in the Bengal Basin. The new alluvial/char lands, the evolution of alluvial land law and the political norms of land administration during pre and post-independence Bangladesh clearly suggest that the char people remain marginal in context of ownership of new charlands and are dominated by powerful landowners from the mainland. As a result, a significant proportion of char dwellers lead a precarious life and are unable to move out of poverty. The 1st National Char Convention of 2015 and the recently adopted Bangladesh Delta Plan 2100 recognize the need for addressing the charland issues, including review and updating of laws and regulations concerning alluvion and diluvion to improve the efficiency in char land administration. It further rightly calls for the establishment of a data bank, using the Management Information System (MIS) for *khas* land, fallow land, acquired land and char land for national policy purposes.

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Chapter 5
Char Dwellers' Right to Development in Bangladesh

Indrani Sigamany and Jay Drydyk

Abstract This chapter examines life in the charlands of Bangladesh in the context of the 1986 *Declaration on the Right to Development* and the 1998 *UN Guiding Principles on Internal Displacement*. On the chars, the right to development remains starkly unfulfilled. Focusing on the poverty of the char communities, the broader components of equality, access to development and resources are used as a framework of analysis. The evidence reveals that underlying the poverty and high rate of inequality of the char communities are poor governance and a lack of structures, which facilitate self-determination. 'Self-determination' in this chapter means the power to make decisions and to have control and agency over one's life, and *not* the legal right to self-government. These human rights concerns are compounded by the causes of people's prior migration onto the chars. A principal driver of that migration has been exclusion from any benefits of development on the mainland, which also contravenes the Right to Development. From this perspective, the migrations that have populated the chars constitute displacement by human rights contravention, which is one of the grounds for recognizing char dwellers as Internally Displaced Persons. Accordingly, the Right to Development and the Guiding Principles on Internal Displacement jointly call for addressing shortfalls in development, health, education, and self-determining governance on the chars.

Keywords Char dwellers · Human rights concerns · UN guiding principles · Right to development · Bangladesh

Introduction

This chapter examines life in the charlands of Bangladesh in the context of the 1986 *Declaration on the Right to Development* and the 1998 *UN Guiding Principles on Internal Displacement*. In light of these rights and principles, it is found that we that

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both people's migration onto the chars and their conditions of living there raise human rights concerns that call for special attention. It begins by reviewing the origins, content, and justification of the Declaration on the Right to Development (DRTD). Special attention is drawn to the definition of the 'development' to which people have a right. In particular, it calls for improvements in well-being and in fulfillment of other rights, including health and education; these gains must be shared equitably throughout the population; and development processes to achieve these outcomes must be based on free participation. It is then considered whether these requirements have been fulfilled. Not only are livelihoods more difficult on the chars, but social and economic rights are comparatively unfulfilled. Moreover, evidence reveals that underlying the poverty and high rate of inequality of the char communities are poor governance and a lack of structures which facilitate self-determination. By 'self-determination' we mean people's power to make decisions and to have control and agency over their lives, not the legal right to self-government.

Finally considered are the criteria for 'internally displaced persons' under the *Guiding Principles*. Here, it is argued that migration onto the chars qualifies as internal displacement insofar as their exclusion from prospects of development on the mainland—contravening their right to development there—was a principal driver of their migration. It is concluded that, according to international law, the char dwellers are entitled to special attention and support by the Government of Bangladesh because their right to development has been contravened twice in succession.

The Right to Development

The Declaration on the Right to Development was adopted by the General Assembly of the United Nations in 1986 (UN 1986b). Its main proponents were members of the Non-Aligned Movement (NAM), comprised largely of low- and middle-income developing countries. Frustrated by the proclivity of the great powers to subordinate the interests of developing countries to Cold War rivalries and agendas, as well as to their own economic interests, NAM had been seeking over a fifteen year period to introduce changes to many of the ways in which developing countries were disadvantaged in the international systems. In the 1970s their focus was on changes to international rules governing trade, finance, and debt, as outlined in the 1974 *Declaration for the Establishment of a New International Economic Order*. Within a decade of its adoption, however, this ambitious declaration was sidelined altogether by the neoliberal Washington Consensus, which became hegemonic. In response, NAM rallied support for a declaration that would at least establish a foothold for the interests of developing countries within the General Assembly, and that was the Declaration on the Right to Development (Marks 2019). The Declaration was proclaimed by the General Assembly on 4 December 1986, with one country opposed (i.e., the USA), eight abstentions, and 146 countries in favor, including Bangladesh (UN 1986b). The Declaration itself was a product of many years of careful thought by eminent legal thinkers. The idea of a right to development was first proposed in 1972 by Senegalese

Judge Keba M'Baye; five years later the Commission on Human Rights (then chaired by Senegal) called for a study of the idea, and such a study was produced in 1979 under the auspices of the UN Secretariat; it was written by Philip Alston, who is now recognized as an eminent scholar and champion of human rights (Marks 2019).

The Right to Development is not merely a right to economic growth, nor merely to basic needs, nor merely a right to relief from extreme poverty. Rather, it has been formulated very carefully around a complex conception of inclusive development. What is the development to which people have a right? First, it is inclusive of all human rights, including social and economic to health, education, and housing: '[t]he right to development is an inalienable human right by virtue of which every human person and all peoples are entitled to participate in, contribute to, and enjoy economic, social, cultural and political development, in which all human rights and fundamental freedoms can be fully realized' (UN 1986a: Art. 1). Second, it is inclusive of the entire population, concerned both for their well-being and equity: '… development is a comprehensive economic, social, cultural and political process, which aims at the constant improvement of the well-being of the entire population and of all individuals on the basis of their active, free and meaningful participation in development and in the fair distribution of benefits resulting therefrom' (UN 1986a: preamble). Third, note the emphasis given in this passage to free and meaningful participation: the development to which people have a right is meant to be inclusive of their agency.

If development is conceived in this way, there are many lines of justification for a right to development. These are identified in the preamble. Since development involves progressive realization of all other human rights, it is mandated by provisions laid down in the *Universal Declaration of Human Rights* 'that everyone is entitled to a social and international order in which the rights and freedoms set forth in that Declaration can be fully realized' (UN 1986a: preamble). It is likewise mandated by the principle of equal rights 'without distinction as to race, sex, language or religion' (UN 1986a: preamble). Further, justification for the right to development derives from the rights of peoples to self-determination and therefore also to 'elimination of the massive and flagrant violations of the human rights of the peoples and individuals affected by situations such as those resulting from colonialism, neo-colonialism, apartheid, all forms of racism and racial discrimination, foreign domination and occupation' (UN 1986a: preamble). Yet this right to national self-determination in development is focused on and limited to promoting and governing development of the right kind:

> States have the right and the duty to formulate appropriate national development policies that aim at the constant improvement of the well-being of the entire population and of all individuals, on the basis of their active, free and meaningful participation in development and in the fair distribution of the benefits resulting therefrom. (UN 1986a: Art. 2, par. 3)

With this in mind, has the Right to Development been fulfilled in the case of char dwellers in Bangladesh? This question can equally be raised in the case of the multitude of poverty-stricken people living in areas other than chars in Bangladesh. However, our focus here is on chars and char regions in the country.

Poverty in the Chars

As recently as sixty years ago, the extremely fertile river lands of the northwest chars were only used as seasonal grazing land for cattle. This changed as the mainland population grew rapidly, resulting in more permanent migration to the chars (Pritchard et al. 2015). The unforgiving seasonal river movements heighten the risk of erosion and sudden flooding of the chars, destroying both habitats and livelihoods of families. The shifting rivers are known to inundate char islands in half a day and if unlucky, a family could lose everything, leaving the char communities among the most vulnerable in the country (Pritchard 2020). The impacts of erosion and displacement and their various dimensions are highlighted throughout the book (see particularly Chap. 12 through 20).

Governance in Bangladesh is highly centralized, and resources trickling down to local governments are not abundant. The priorities are set by the central government. The char lands, isolated and remote, have traditionally been low priority for the central government. As Matt Pritchard from CLP states, there are 'no jobs, no factories, no school. The local governments have no resources and they are very stretched. Places like the chars are overlooked. The healthcare is almost non-existent, for which people have to travel to the mainland. Transport, however is very difficult. In the dry season, there are no roads, therefore sand is loose and makes travel and markets difficult. There is no government transport at all. People wait for the rains, as the rivers are their motorways, and they can use their own boats. Flooding is inevitable.' (Pritchard 2020: personal interview). The 2007 and the 2017 floods were unusually heavy, causing high mortality. Homes are often built on plinths with the help of NGOs. In really heavy flooding, the plinths which are engineered piles of sand, can get eroded, affecting the stability of the homes (also, see Chaps. 14 and 15).

This instability has a permanence in the lives of char dwellers and only the poorest families, being pushed off the mainland by population congestion, coupled with landlessness, therefore, migrate to the chars as a survival strategy (Zaman 1988; Pritchard et al. 2015). Despite the obvious vulnerability of the char lands, for the communities, the access to land and potential for new livelihoods has created a migratory pull, though the chars house very poor people living their lives, barely able to survive. The biggest asset of the char communities is their labor. When planting and harvesting rice season no longer requires the men to be on the chars they migrate seasonally to the mainland to sell their labor for poorly paid wages. As a result, food insecurity is very high, with high malnutrition and hunger. The BMI is around 17–18 and the stunting and wasting of children around 35% (Pritchard 2020). Most food eaten by char communities are grown by them on charlands such as growing their own pumpkins, rice, corn. The chars constitute a diverse agricultural landscape and char soils can be very fertile. Food security is one of the critical poverty indicators: 'Are you able to eat three times a day?' If they were eating three times a day, they didn't consider themselves very poor. Though they could be eating rice three times a day, they could still be nutritionally badly malnourished, without access to diverse food groups.

Traditionally, char dwellers have no source of livelihood for about four to five months a year, with no income at all, till civil societies stepped in with programs targeted at improving livelihoods, providing basic health support initiatives and supporting long-term primary education. Extreme poverty reduction programs have been funded by civil society, the international community and to some extent the Bangladeshi government. The most established extreme poverty reduction programs have been delivered through three large programs under BRAC's Challenging the Frontiers of Poverty Reduction Targeting the Ultra-Poor (CFPR-TUP),[1] Char Livelihoods Program (CLP), and Eradicating Extreme Poverty/Stimulating Household Improvements Resulting in Economic Empowerment (EEP/Shiree). The 'graduation' concept is about families or individuals moving up from 'ultra-poor' to other gradations of 'poor,' including services such as asset transfers and capacity building.[2]

The feminization of poverty is evident in the fact that women of the chars are more disadvantaged and have less voice (see Chap. 19). Traditionally, the women, who are almost entirely Muslim, do not move out of the chars. The migration to other chars or other areas of Bangladesh therefore, is almost always male. This leaves a large percentage of female-headed households in char lands (Pritchard 2020). A very big cause that compounds poverty and debt in the char communities is their commitment to the cultural practice of dowry (Haneef et al. 2014; also see Chap. 19). Dowry is constitutionally illegal in Bangladesh, but nevertheless deeply ingrained cultural practice in the char community, not only causing deep impoverishment, but also reinforcing the historical perspective of women as a commodity to be sold in marriage. Women rarely have an independent income. One of the civil society organizations working in the char lands, the CLP, recognizing that independent income is a big indicator for boosting empowerment, offered livelihood programs for women in the char communities. Ninety-eight percent of the women in the program chose cattle rearing. CLP offered training for village savings and cattle rearing, and calculated that independent income had the biggest impact on 'graduating' from extreme poverty in the hierarchical measure that has been developed by Bangladesh' development community and civil societies (CLP 2016).

The microenterprises which slowly increased productive assets of women and therefore of families, created an inevitable change in women's empowerment which though slow was visible (Watson and Hannan 2016). For example, the younger women are opting for two children, dropping the fertility from up to 12 children to 2.1 per woman. Contraception is available, used and accepted. Currently there are about 3.89 people per household. Families are well planned and age staggered, which is a significant indicator of female empowerment. (World Bank 2019; Pritchard 2020). Fifty percent of households have access to mobile phones, and have exposure to current events in other countries (Pritchard 2020). Women getting more independent is evident by how expectations of educational opportunities, and the ability to independently move around physically, are no longer be tied only to the home (Chap. 18

[1] BRAC is Bangladesh's largest NGO and it is also the largest NGO in the world.

[2] These programs have received funds from international governments such as UKAid.

discusses outmigration of women for jobs in the garment industry). Village Development Committees (VDC) were set up by NGOs such as CLP to encourage and establish local governance and decision-making platforms, which CLP reports have been successful. (CLP n.d.).

Fundamental Freedoms to the Right to Development

One significant principle of the 1986 *Declaration on the Right to Development* is 'Fundamental Freedoms.' In the context of the char communities, the fundamental freedoms fall far short of their lives, where they do not enjoy the freedom to live a life of security, the freedom to educate themselves and their children, the freedom to command an income which pushes them above the poverty line, the freedom to have access to tenure security and the freedom to participate in their own development. Development is referred to as a 'constant improvement and well-being of the entire population and all individuals on the basis of their free, active, and meaningful participation in development and in the fair distribution of benefits from development'. These rights to full participation of economic, social, cultural and political development are referred to as inalienable, and correspond with the two *International Covenants on Human Rights* (UN 1966a, b). In the Declaration, the human being is recognized as being central to the process of development, and development policies should be framed with the individual being the 'main participant and beneficiary of development.' Unfortunately, in practice, millions around the world have remained on the fringe of development, not to speak of being participants and beneficiaries.

States have a duty and a right to frame development policies for this improvement of well-being of all. States also have a duty to create national and international conditions to facilitate the realization of these rights for all. Most importantly, states shall take resolute steps to protect the human rights of people. Article 8 is particularly significant, as it gives states the obligation to undertake 'all necessary measures for the realization of the right to development.' If these terms had been met, or even an attempt been made to meet these rights by the Bangladeshi government, the poverty on the chars would not currently be so abject.

In 2015, The *1st National Char Convention* 2015 was organized in an attempt to focus the attention of the central government and policy makers on the development of char lands. There was a substantial number of vocal representatives from the chars, besides representatives from the government and policy makers, local NGOs and INGOS and academics. The discussion centered upon the government's responsibility to mobilize resources to char areas. The report of the convention states, 'Although it is increasingly recognized that the chars need assistance to alleviate poverty, national development policy makers and planners have yet to focus on longer-term sustainable development strategies for the chars. The budgetary allocation for infrastructure and service provision does not consider the unique requirements of the conditions imposed by the chars' geographical situation. Access to health and education services and agricultural extension is limited in char areas due to their isolation and lack of accountability of the service providers' (Krishibid Institution 2015:6). We can conclude that neither the fundamental freedoms, nor the constant improvement and well-being contained in the Declaration on the Right to Development, are not recognized nor granted by the Bangladeshi government as inalienable rights of communities in the char lands.

The next point of debate within Bangladesh in relation to the Declaration is, 'the human being is recognized as being central to the process of development, and development policies should be framed with the individual being the 'main participant and beneficiary of development.' From the available evidence, despite empowerment programs offered by NGOs, the right to self-determination to participate in their own development on a macro-scale is not evident. The char communities remain isolated from central government policies for development. The village development committees set up the civil society organizations in the chars don't seem to interact with the three-tier local governance institutional structures called *zila parishad* (apex tier), *upazila parishad* (intermediate tier), and *union parishad* (the lowest tier) which are part of the Bangladeshi Rural Local Government System (RLGS). Tofail Ahmed, in his article comparing the RLGS to the Panchayati Raj or village councils in India, writes that the RLGS 'remain non-functional since implementation of the Act in 2011' (Ahmed 2016:164). The char communities, despite being officially part of the system of local government, remain practically isolated, marginal and the extremely vulnerable do not have the voice and/or the platforms, which would facilitate accessing their rights to development.

The emerging issues contributing to poverty are varied. They include a lack of structured governance dedicated to prioritizing poverty alleviation. This causes a disempowerment that is visible in aspects such as low participation in decision making and making their voice heard for development opportunities. The absence of government welfare, social and economic interventions have also created a possible dependency on civil society organizations (CSOs), who have taken on a huge responsibility in trying to fill the gaps left by government, but this could be making it easier for the government to continue to neglect development in the chars. The services and capacity building, and the organization of village development committees (VDCs) that the CSOs such as CLP have pursued contributed hugely not only to development on economic terms such as livelihoods and income, but also to social aspects such as rights, empowerment, strong gender equity, and increased agency and decision making. The challenge for CSOs working closely with communities is to work with empowerment, self-determination and power sharing alongside services offered for livelihoods, healthcare and education.

What is harder to put into place systemically is the ability of the community to demand and establish accountability from the government for services and improvements in health, education, water and sanitation, employment, land rights, agricultural services, and a social safety net. These are as yet not in place as a government obligation for char communities, though it is the year 2020, which creates a strong contrast with the services offered to communities external to the chars and situated on the mainland. The Bangladeshi government does not meet the duty and responsibility of international norms such as 'States have a duty and a right to frame development policies for this improvement of well-being of all. States also have a duty to create national and international conditions to facilitate the realization of these rights for all' (UN 1966a, b: Art. 2). Governance structures in Bangladesh have not been strong enough to respond to the ubiquitous poverty of the charlands.

Governance (or Lack Thereof) in the Char Communities of Bangladesh

Bangladesh is a relatively young and fragile democracy, with institutions that might not be robust enough to support good governance. Ara and Khan write that democracy in Bangladesh is floundering, weighed down by factors such as corruption, bureaucratic inefficiency, nepotism, inefficient distribution of resources, and the 'politicization of administration' (Ara and Khan 2006: 93). In 1971, emerging as a newly liberated country from what used to be East Pakistan, the country began massive war reparations. After its violent and bloody birth, as the new nation of Bangladesh regenerated, governance and the democratic process in Bangladesh took a backseat for the next two decades (Khan 2018). Khan points out the concept of governance becomes blurred when leaders do not necessarily differentiate between the public service with duty to citizens and domination and abuse of power (Khan 2018). In this complex equation of non-transparency, poor accountability, a weak rule of law, and human rights violations, communities in the char lands are of very low priority (Ara and Khan 2006).

The two conclusive aspects related to the extreme poverty in the chars and the chronic vulnerabilities of livelihoods and homes being washed away by seasonal riverine movements, point to the inadequacy of governance in Bangladesh. Ara and Khan describe governance as 'the exercise of economic, political and administrative authority to manage a country's affairs at all levels. It comprises the mechanisms, processes and institutions through which citizens and groups articulate their interests, exercise their legal rights, meet their obligations and mediate their differences' (Ara and Khan 2006: 91). The two aspects of governance that are evidently missing from the lives of the char communities are local governance structures and a lack of social protection from central government for the roughly six million people inhabiting the chars (Ali 2015). The lack of community platforms, which might facilitate access to voice, agency and local political participation, is unfortunate.

The consensus has been that the national government has neither prioritized policies nor ensured budgetary allocation for development of the chars. The temporariness of the riverine geography of the chars demands a unique governmental response which is not forthcoming. Service provisions such as healthcare, education and agricultural support from the government are not adequately available and/or non-existent in some instances. The one strong spoke in the wheel of governance in Bangladesh has been the role of a strong and vibrant civil society which has stepped in to fill gaps in service provision to vulnerable and impoverished sections of the country, including the char communities. Civil society organizations who have been the main providers of these services have joined the char populations in demanding more comprehensive, sustainable governance. These demands initially took shape in the form of the *First National Char Convention* in 2015, with the slogan 'Let the Light of development spread over the Chars' (Krishibid Institution 2015:7). The Convention called 'to end all discrimination' and demanded a government strategy, which would mobilize resources for the chars (Krishibid Institution 2015:7).

Ahmed and Rashid (2015) refer to 'governance deficits' in Bangladesh, using the example of a lack of delivery of basic services to support extremely poor and vulnerable households. For char communities protection against risks of losing habitat and livelihoods as the waters rise seasonally in the riverine delta, is vital. The Bangladeshi government's National Social Protection Strategy (NSPS) aims at working with the existing safety net programs more efficiently, and has a long-term goal to 'Build an inclusive SPS for all Bangladeshis that effectively tackles and prevents poverty and rising inequality and contributes to broader human development, employment and economic growth.' Ahmed and Rashid claim that the existing social safety net programs have limited coverage, are poorly funded and are managed by a fragmented bureaucratic setup, which points to inadequate governance, because of which the char communities have not had access to social protection, remain poor and vulnerable to risks (Ahmed and Rashid 2015).

Char Dwellers as an Internally Displaced Population

We have argued that the Right to Development has not been fulfilled for the char dwellers of Bangladesh. This argument on its own provides sufficient reason to conclude that the chars raise significant human rights concerns. Yet there is also a further supplemental argument, which we present in this section. This argument concerns the historical displacement of people from the mainland onto the chars, and it invokes another body of international law, the *Guiding Principles of Internal Displacement*.

The Guiding Principles were formulated to fill a perceived gap in the formulation of international law pertaining to forced migration. When forced migration drives people across borders, they may be protected by the 1951 Refugee Convention and the subsequent 1967 Protocol (UNHCR 2020). However, there are no similar conventions or protocols to protect people who are forced to migrate but do not cross into another country. This gap became glaring in the 1990s when the numbers of internally displaced people increased shockingly. While it was estimated in 1982 that 1.2 million people were internally displaced in 11 countries, by 1995 there were an estimated 20–25 million IDPs in more than 40 countries, outnumbering the border-crossing refugees by nearly two to one (IMDC 2020). In response, Sudanese diplomat Francis M. Deng was appointed first by the Commission on Human Rights, then by the General Assembly, and finally by the Secretary General to formulate clear human rights-based standards for the protection of internally displaced people. The Guiding

Principles which emerged from this process did not make new international law; rather they are carefully based on previous declarations, conventions, and accepted interpretations. While they are not binding on states, the *Guiding Principles* have gained considerable authority since their adoption in 1998, not only by the General Assembly, but also by regional organizations and states that have embedded them in their own regulations and legislation (IMDC 2020).

The Guiding Principles define 'internally displaced people' as those 'who have been forced or obliged to flee or to leave their homes or places of habitual residence, in particular as a result of or in order to avoid the effects of armed conflict, situations of generalized violence, *violations of human rights* or natural or human-made disasters' (UN 1998: Introduction, Par. 1). Three of the drivers specified in this definition are life-threatening circumstances: armed conflict, generalized violence, and disaster. Many of the people who migrated to the chars, we contend, were internally displaced by exclusion from any prospect of sharing in development on the mainland, and this exclusion contravenes the Right to Development. It was this violation of their human rights by which they were 'forced or obliged to flee or to leave their homes or places of habitual residence.' These char migrants therefore qualify as internally displaced persons. One common explanation of why people move onto char lands is 'population pressure' (Sarker et al. 2003:61; Pritchard et al. 2015:35). Zaman cites explanations of this kind going back to 1938 (Zaman 1988, 1991). Underlying these demographic accounts, however, there are more specific drivers.[3]

The principal push factor underlying migration to the chars is poverty and precarious livelihoods on the mainland; 'Most of them said that their economic plight compelled them to go for such a venture' (Baqee 1998:106). Throughout Bangladesh, long-term migration and seasonal migration have been found to have somewhat different drivers. While it is a need for income diversification that drives seasonal migration, long-term migration is driven by poverty (Kabir et al. 2018). Indeed, Zaman has pointed to 'a process of pauperization' (Zaman 1988:94) as the underlying factor. Wisner et al. identify unequal access to land as another key underlying factor. '"Population pressure" is, in our view, an effect, and not a cause, in this situation.' (Wisner et al 2004: 69).

The primary pull factors are availability of land and livelihood opportunities on the chars (Zaman 1991) and social networking with people already there (EGIS 2000). The two are inextricably connected, since it is through social networks that people come to know about opportunities on the chars. In his study of inter-char displacement and resettlement, Zaman found that family and other social connections play a large role: 'assistance received from friends and relatives is wide ranging, from moral support and advice on destination to cash loans, free use of land for homestead, and food and free labor at the time of move.' (Zaman 1988:114) The presence of extensive family networks on the chars, in addition to their readiness to assist family members in secondary resettlement, confirms that kinship assistance also played a role in primary

[3] It is also possible that those who find the option of settling in the chars consider themselves luckier than some others like them who desperately want to find access to chars but for some reason cannot and hence linger on miserably in the mainland.

displacement and resettlement onto the chars. Lahiri-Dutt and Samanta, using data from neighboring India, confirm this: 'In most cases, the migrants left home after establishing a connection with at least one contact person, such as a neighbor or villager who had previously left the source region and who then provided them with shelter.' (Lahiri-Dutt and Samanta 2013:117).

One of the driving factors here is people's perception that there was no prospect for improving their well-being in their initial circumstances; this may be aggravated by perception of inequity if well-being is improving for others in that community or elsewhere in the society. Migration appears to them as the only path of 'free and meaningful participation' by which their well-being can improve. This exclusion from development is not only a contravention of the Right to Development; it is a contravention by which people 'have been forced or obliged to flee or to leave their homes or places of habitual residence' on the mainland to migrate onto the chars. This raises an additional human rights concern regarding the char dwellers as an internally displaced population. The *Guiding Principles,* therefore, appropriately underline the importance of better fulfilling the char dwellers' rights, particularly to security, protection of law, adequate standard of living, health care, and education (UN 1998, Sect. 3). These standards cast an unfavorable light on the governance deficits we noted in the previous section.

Conclusions

The leading question in the given context is whether the Right to Development has been fulfilled on the chars of Bangladesh. This question cannot be evaded by thinking that the Right to Development is somehow foreign or extraneous to the affairs and of Bangladesh. It cannot be argued that the Declaration interferes with the sovereignty of the country, because Bangladesh was among the 146 countries who voted it into existence in 1986. Moreover, this right derives from the right of peoples to self-determination, especially in response to foreign domination, and it was brought into existence by an alliance of developing countries like Bangladesh. The imperative to realize the right of development for char dwellers is reinforced by the fact that so many of them have been displaced onto the chars by failures to realize that right elsewhere in the country. Judging by outcomes in education, health, and food security alone, it is undeniable that in these dimensions the right to development is not being fulfilled on the chars; moreover, these deficits are compounded by a feminization of poverty. This constitutes a clear failure to achieve the 'constant improvement of the well-being of the entire population and of all individuals' that is mandated by the Declaration.

In this chapter we have indicated a number of ways in which these failed outcomes result from failed governance. Fiscal allocations for functions as basic as transportation, health and education do not adequately take the unique conditions of the chars into account. Existing social safety net programs have limited coverage, poor funding and fragmented management. There has been little impetus for change within government, which has given little priority to poverty alleviation on the chars, and this has caused a disempowerment that is visible in aspects such as low participation in decision making and making their voice heard for development opportunities. Hence development on the chars has also failed by the standard of 'free and meaningful participation in development' (UN 1986a: Art. 2, par. 3).

The role of civil society has been double-edged. On the one hand, a strong spoke in the wheel of governance in Bangladesh as a whole has been the role of a strong and vibrant civil society which has stepped in to fill gaps in service provision to vulnerable and impoverished sections of the country, including the char communities. On the other hand, the absence of effective government interventions in the chars may also have created a possible dependency on civil society organizations. Lacking, to date, has been effective ability of the community to demand and establish accountability from the government of services and improvements in health, education, water and sanitation, employment, land rights, agricultural services, and a social safety net. A drive for greater accountability has been initiated by the National Char Convention of 2015. This could possibly lead to a strategy of rights-based-development (Gready and Ensor 2005; UNHCHR 2006), in which the rights-holders (here the char dwellers) organize to hold the duty-bearers (government) accountable for fulfilling rights to education, health, an adequate standard of living, and participation in development decision making. Whether such a strategy can succeed in the difficult conditions of the chars remains to be seen.

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Part III
Chars in Bangladesh: The Geo-Physical Context

Editors' Note

Part III, consisting of six chapters, is devoted to the analysis of geomorphology of char formation in the delta and floodplains of Bangladesh. Chapter 6 by Harun Rashid/MK Rahman and Chaps. 7–9 by a team of authors (Iffat Huque/Knut Oberhagemann/Maminul Haque Sarker and others) deal with geomorphology of the riverine and estuarine chars, and the use of remote sensing data in studying the dynamics of riverine and coastal chars in Bangladesh. The processes related to erosion, sediment transport and deposition are explained in these chapters. Chapter 10 by Hugh Brammer describes the soil types found in five different char regions of the country, with intermittent observations on prospects of crop agriculture in these different areas. In Chap. 11 Shampa and others evaluate future risks of climate change impacts on riverine and coastal chars in Bangladesh. The chapters contribute to a better understanding of the river morphology and estuary development during the last half century, significantly facilitated by the application of remote sensing technology.

It is to be noted that the various authors in their respective chapters in this part have referred to chars as islands, channel bars and sandbars. There are also issues with regard to size, height (i.e., above or under normal flood level) and whether they are sandy or vegetated. There are mid-channel island chars and chars along the riverbanks, called attached chars. The sandbars in meandering rivers in the floodplains are mostly visible during low water level in the winter/dry season. These sandbars continue to grow with additional deposition and may disappear as a result of the dynamic processes in char formation. Therefore, chars or charland as described in the various chapters here include the broad range of sandy and alluvial deposits in the floodplains and the estuary/delta. While all chars are vulnerable to different degrees of flooding and erosion, the coastal chars are faced with the imminent additional hazard of inundation due to sea level rise as a consequence of climate change.

Chapter 6
Geographical Perspectives on Riverbank Erosion, Charlands, and Floodplains

Harun Rashid and Munshi Khaledur Rahman

Abstract Based on two-dimensional planform data on channel area and distance, interpreted from non-sequential snapshots of the Google Earth satellite imagery, the main objective of this study is to analyze spatial variations in morphological instabilities in major rivers of Bangladesh. The results indicate that while riverbank erosion is a pervasive problem in all of the major rivers of Bangladesh, there are significant spatial variations in densities of channel bars from one river section to another. It further relates such channel instabilities to longer-term lateral channel migration responsible for successive bank erosion and accumulation of charlands and floodplains.

Keywords Riverbank erosion · Charlands · Estuarine chars · Floodplains

Objectives of This Study

The term charlands has been used broadly in this book to refer to a range of highly dynamic alluvial deposits, including (a) island chars or channel bars in braided rivers, (b) attached chars, such as point bars in meandering rivers or channel bars of braided rivers which are attached to river banks, (c) bands of sandy and alluvial deposits along a riverbank irrespective of the channel pattern, and (d) different forms of sandy and alluvial deposits in a river estuary (FAP 1993). The Bengali word char and its anglicized adaptation charland may be translated literally as sand deposits at anyone of

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the above depositional environments. In most of the riverine areas of Bangladesh, the term char has an implication for exposed sands or alluvial deposits. Relatively small incipient chars (channel bars), which could be growing further or could be short-lived as ephemeral chars, are almost always composed of sands and silts. Whenever such channel bars grow in size into fully developed, vegetated alluvial islands the term char becomes tentative, although vernacular names of some of these large alluvial islands may include the word char, such as Char Hijla. Many of these islands continue to grow by successive accumulation of sands and silts along their perimeters. The latter deposits are invariably called chars or charlands. The present chapter is an attempt at demonstrating that charlands are the outcome of morphological instabilities of alluvial channels in the form of accelerated bank erosion and deposition/accumulation of sediments. It further relates such channel instabilities to longer-term lateral channel migration responsible for successive bank erosion and accumulation of charlands and floodplains.

Unstable Rivers of Bangladesh

Environmental Settings

The Ganges (Padma), the Brahmaputra (Jamuna), and the Meghna—the three large river systems of the Indian sub-continent—have coalesced in the Bengal basin to form the world's largest delta (Goodbred et al. 2014). The Bengal delta is also one of the youngest and most dynamic alluvial environments in the world, as the preceding geological studies indicate that current morphological instabilities of its river systems may be traced back to at least 5000 years (mid-Holocene). During this entire period, the delta surface has been reshaped by extensive river sedimentation, channel migration and channel avulsion (stream capture or takeover of one stream by another). The diversion of the Brahmaputra River into the current Jamuna channel had occurred in less than the past 250 years. Many tributaries and distributaries of major rivers have been changing their courses during recent years. Thus, morphological instabilities in rivers of Bangladesh are not new.

Major morphological features of the Bengal delta include extensive river floodplains and large numbers of meandering and braided rivers (rivers with channel bars/chars) and their associated smaller-scale landform features. Overall, the delta surface has been dissected by hundreds of stream channels (including smaller subtributaries). At least 80% of the land area of Bangladesh consist of floodplains of these rivers. Most of the rivers are free to wander across the floodplains without major structural obstructions. The Madhupur Tract (an elevated block which is also called Madhupur Pleistocene Terraces) and the Barrind Tract are two notable geological structures that provide local geological controls against lateral channel migration (Fig. 6.1). Major structural depressions, such as the Sylhet Basin and the Gopalganj

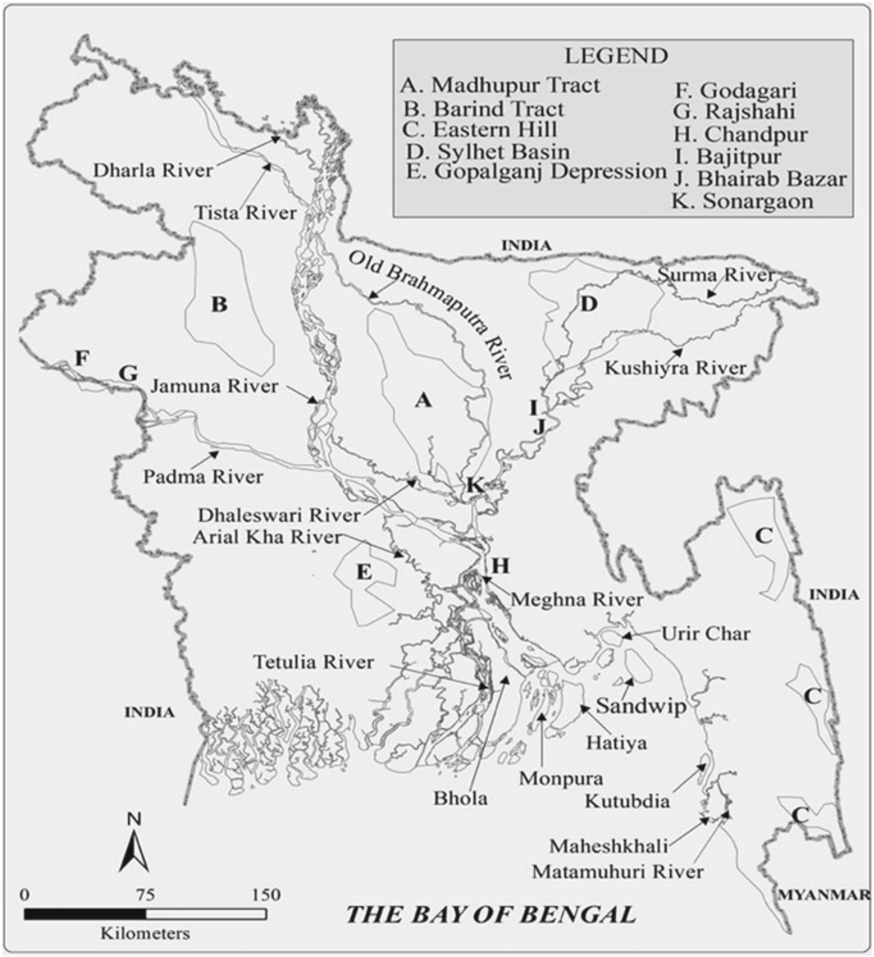

Fig. 6.1 Rivers of Bangladesh. *Source* Munshi Khaledur Rahman)

Depressions, act as drainage sinks for adjacent river systems. The Eastern Hills, occupying about 10–15% of the land area of Bangladesh, provide a stark contrast with the relatively flat landscape of the floodplains. The orientation of rivers of this region is determined largely by geological controls, especially by the north–south alignment of major valleys. Similarly, riverbank erosion is controlled largely by the steepness of valley slopes and variations in lithological (rock) characteristics of hillslopes. Charlands are not a significant feature of the Eastern Hills.

Method of Assessing Instabilities in Rivers of Bangladesh

The stability/instability analysis is based on the premise that a stable river has a single and simple sinuous channel, i.e., a meandering river, with very little erosion and deposition problems. Such a river is often characterized as a *graded stream* or a *stream in equilibrium*, i.e., a stream with a balance between its discharges and sediment load.

The term "accelerated" bank erosion in an unstable river implies erosion rates exceeding that expected from a graded stream. Similarly, accelerated sediment deposition in the form of charlands implies channel instability. Two-dimensional data on the length of bank erosion, channel width, channel areas, and areas of attached chars and island chars, which were measured from non-sequential snapshots of the Google Earth satellite imagery using it's "distance and area tool," provided the basis for interpreting the nature of channel instabilities in three major rivers of Bangladesh, namely the Jamuna, the Padma, and the Meghna. In addition, sequential historical satellite imageries were used to estimate rates of bank erosion in Bhola and Kutubdia, which typify morphological instabilities of two estuarine islands and charlands.

Bank Erosion

Instability analysis indicates that there are significant spatial variations in exposure of the banks to river flow (Tables 6.1 and 6.2). Thus, large parts of the banks of the Jamuna and the upper Padma are protected from erosion by attached chars during the low-flow season (i.e., the period of the Google Earth satellite imagery). This implies that most of the bank erosion occurs during the high-flow season when the attached chars are submerged, exposing the banks to the impact of flowing water. There are fewer attached chars along the lower Padma and most of the banks of the Meghna. Consequently, most of their banks are in direct contact with the river flow (Tables 6.1 and 6.2). Morphological characteristics of bank erosion in all of the rivers seem to be similar. Most of the erosional banks display one or more of the following four morphological features: (i) bank caving: evident from collapsed banks directly plunging into river water or on to the attached chars; (ii) bank slumping: evident from crescentic ridges of slumped materials below the bank; (iii) steep erosional cliffs often plunging directly into river water or on to the attached chars; and (iv) lower cut banks either above attached chars or directly along the water level.

Table 6.1 Jamuna River: instability analysis of a sample reach

Length of the Jamuna in Bangladesh (between the Bangladesh–India border and junction with the Padma)	230 km
Length of the sample reach between two right-bank tributaries (Dharla and Tista)	30 km
Channel pattern	Braided: major braid-field
Channel bifurcation	2–3 major sub-channels
Dominant bank characteristics	Erosional banks with *attached charlands*
Portions of banks in direct contact with river flow (low-flow season)	25–40%
Bank-to-bank channel area across all *island chars, attached chars* and water surface	343 km^2
Areas of *island chars* and *attached chars* (% of channel area)	235 km^2 (68%)
Average channel width across all *charlands* and water surface	11.43 km (range: 10–15 km)
Average width of the river flow, i.e., water surface only	3.62 km
Number of *island chars* and *attached chars*	Island chars: 34–36 Attached chars 10–12
Size distribution of *chars*	Larger *chars* (10–58 km^2): 7 Medium-sized *chars* (1–9 km^2): 17 Smaller *chars* (each smaller than 1 km^2): 22

Source Original table prepared by the authors based on measurements from the Google Earth Satellite Imagery, using its "distance and area tool"

Channel Patterns

The Jamuna

The sample rivers display a continuum of channel patterns, ranging from nearly straight channels to slightly sinuous courses and highly braided pattern. Among the three rivers, the entire 230-km long reach of the Jamuna provides an example of extreme form of braiding which has significant impacts on bank erosion, bank-to-bank channel width, width of the water surface (i.e., the stream channel), and areas of island chars and attached chars. A 30-km long sample reach of the Jamuna, extending from the mouth of the Dharla to that of the Tista (also spelled Teesta), two right-bank tributaries of the Jamuna, typifies the nature of braiding (Table 6.1).

Perhaps, the most striking morphological characteristic of the sample reach is a continuum of channel instability starting from major bank erosion to formation of attached chars below the eroded banks and detached mid-channel island chars forming a vast channel bar field. One of our major findings is that the attached chars

Table 6.2 Morphological characteristics of the Padma River

Channel characteristics	Upper Padma	Lower Padma
Mid-channel length	**230 km** (between the Bangladesh–India border and junction with the Jamuna)	**110 km** (between the junctions with the Jamuna and the Meghna)
Mid-channel length of the sample reach	80 km (Between the border and Rajshahi)	110 km (Entire reach)
Channel pattern	Braided pattern in a sinuous course	Nearly straight channel (sinuosity: 1:1.03) with some braiding
Channel bifurcation	Mostly two sub-channels	Mostly single channel
Dominant bank characteristics	Erosional banks with large numbers of *attached chars*	Erosional banks with limited numbers of *attached chars*
Portions of the bank in direct contact with river flow (low-flow season)	48%	75%
Bank-to-bank channel area across all *island chars, attached chars* and water surface	544 km^2	1040 km^2
Areas of *island chars* and *attached chars* (% of channel area)	384 km^2 (71%)	612 km^2 (59%)
Average channel width across all *charlands* and water surface	6.8 km	10–10.4 km
Average width of the river flow, i.e., water surface only	2.0 km	4.28 km
Number of *island chars* and *attached chars*	Island chars: up to 20 small incipient chars Attached chars: 10–12 large chars	Island chars: 40–42 small incipient chars + 7 large island chars Attached chars: 5–6
Size distribution of *chars*	26–95 km^2: 5 11–25 km^2: 3 2–10 km^2: 5	10–150 km^2: 14 1–9 km^2: 19 < 1 km^2: 14

Source Original table prepared by the authors based on measurements from Google Earth Satellite Imagery, using its distance and area tool

and island chars in the sample reach occupy about two-thirds (>68%) of the total bank-to-bank channel area. Another significant finding relates to the size distribution of these chars, which shows that only seven larger chars (island chars + attached chars) occupy about one half (47%) of the channel area. Medium-sized chars (17 chars) account for about 20% of the channel area, whereas 22 smaller chars, each measuring less than 1 km^2, account for less than 2% of the channel area. The largest island char within this sample reach has an area of about 30 km^2 and measures about 9.2 km in length, compared to about 160 km^2 in area and 25–30 km in length (depending on how the length is measured) for the largest island char in the Jamuna River near Kazipur (in Sirajganj district about 100 km downstream of the Tista). The smallest island char in the sample measures only 0.05 km^2.

The excessive occurrence of charlands in the Jamuna River has an impact on the measurement of channel width. The average bank-to-bank channel width (across all chars) within the sample reach is 11.43 km with a range between 10 and 15 km. This range is maintained throughout the entire 230 km reach within Bangladesh with the exception of a much narrower and relatively stable channel near the Jamuna Bridge (Bangabandhu Bridge), where the channel is only about 4.7–4.8 km wide. More importantly, charlands have a direct impact on the width of the water channels. Thus, when areas of charlands are excluded from the total channel area, the average water channel width is only 3.62 km. Since the Jamuna braided river flows through two to three major sub-channels, on average, each of the sub-channels is barely 1.2–1.8 km wide. It should be stressed here that during high-flow seasons when most of the charlands are submerged, the Jamuna River measures more than 10 km in width at many sections, making it as the widest river of Bangladesh with the exception of the lower Meghna near its estuary. Its overall width is exceeded only by the lower Amazon and some of the sections of the Congo.

The Padma

The Padma has complex channel patterns that differ between its upper and lower reaches as well as from that of the Jamuna. Like the Jamuna, the upper Padma has a braided channel pattern with large numbers of attached chars and island chars, but paradoxically it flows through a sinuous course (with a sinuosity of 1:1.25 vs less than 1:1.05 for the Jamuna). Like the Jamuna, the lower Padma has also a nearly straight channel (with a sinuosity ratio of less than 1:1.05), but it has fewer larger attached chars and island chars to qualify as a truly braided channel pattern. Another important difference between the two reaches is related to the numbers of channels through which the river flows. Whereas the entire 230-km long upper Padma flows through at least two major sub-channels (owing to the presence of several larger island chars), the lower Padma flows mostly through a single wide channel (Table 6.2). As in the Jamuna, nearly three-quarters of the total channel area of the upper Padma (71%) are occupied by attached chars and island chars. Consequently, the average width of the total water surface is only 2.0 km. Since the channel is subdivided into at least two sub-channels, the average width of individual sub-channels is about 1 km or less. In contrast, the average width of the water surface of the lower Padma is significantly greater than that of the upper Padma. There are three main reasons for this. First, there are only limited numbers of larger mid-channel island chars affecting the water channel width. Second, although there are numerous smaller mid-channel bars most of them are incipient and ephemeral chars which have very little or no effect on the width of water channel. Third, larger island chars are situated closer to the banks—three along the right bank and four along the left bank which are separated by relatively narrow sub-channels. The average width of the water channel measured between these island chars on opposite banks is about 4.28 km, compared to 2.0 km for the upper Padma and 3.62 km for the Jamuna.

The Meghna

The Meghna is the most complex river system of Bangladesh because its two main tributaries, i.e., the Surma and the Kushiyara, differ from the Meghna mainstream in channel pattern, channel dimension and the nature of morphological instability. The Surma and the Kushiyara are both classic examples of meandering channels displaying sinuosity ratios of 1:1.5 or higher. Both of them meander through north-eastern Bangladesh for about 250 km each (river distance) before draining into the Sylhet basin, which acts as a drainage sink not only for these two leading tributaries but also for many other rivers adjacent to this structural depression. The Meghna mainstream originates in the southern end of the Sylhet basin carrying the combined flow of both of its tributaries.

The Meghna mainstream can be further subdivided into two distinct reaches based on the complexities of their channel patterns. The upper Meghna has a slightly more sinuous course than that of the lower Meghna. Its sinuosity ratios range between 1:1.1 and 1:1.2, depending on how it is measured: the former along its western main course, a river distance of about 140 km between its beginning near Bajitpur (in Kishoreganj district) and the Meghna-Padma junction near Chandpur, and the latter along its narrower eastern (left-bank) branches (about 150 km). This bifurcation of the upper Meghna channel occurs at a large scale at least at three major bends. It involves a large island char (measuring about 250 km^2), mostly in the district of Comilla, from north of Homna in the northeast to Daudkandi in the southeast. At least, three to four narrower left-bank branches of the Meghna have enclosed nine to ten smaller island chars and a large island char (measuring about 172 km^2), occupying the entire Upazila of Meghna (an administrative sub-district named after the river) and parts of Homna (in the district of Comilla).

Although the upper Meghna channel displays braiding at several major bends, overall it does not necessarily conform to a braided pattern. Unlike the Jamuna and the upper Padma, the upper Meghna is not choked with sediments. There are hardly any incipient chars or ephemeral sand bars in the channel, probably because most of the sediments carried by its tributaries have been deposited in the Sylhet basin. With relatively low sinuosity ratios (1:1.1–1:1.2), the upper Meghna can at best be characterized as a sinuous channel with selected anastomosing bends. It may be further pointed out that the second half of the upper Meghna between Manikganj and Chandpur—a distance of 35 km—has almost a straight channel with a sinuosity of 1:1.04. Because of the appearance of large numbers of big island chars at selected bends, the channel widths vary widely from one section of the river to another.

The lower Meghna is defined here as the 120-km long channel downstream from the junction of the upper Meghna and the Padma near Chandpur to its mouth in the Meghna estuary north of Hatiya Island. As the combined flow of the Padma, Jamuna and Meghna approaches the Meghna estuary, the lower Meghna becomes progressively wider, ranging from 5 to 6 km south of Chandpur to as wide as 16–17 km near its mouth. Like the upper Meghna, the lower Meghna is also clear of smaller island chars. Instead, there are at least five large island chars along its right bank (from north to south): Ibrahimpur (area: 18 km^2), Nilkomol (134 km^2), Char Hijla (68 km^2), and Mehendiganj (102 km^2). Because of their large size, relatively high elevations above the river level, and historical settlements dating back to more than two centuries, it is often difficult to characterize some of these island chars as charlands. For example, Mehendiganj is one of the sub-districts (Upazila) of Barisal and Char Hijla is a part of the Upazila of Hijla (Barisal district). However, these island chars have an impact on the overall channel pattern, which is very similar to that of the upper Meghna. Thus, although the lower Meghna is almost a straight channel with a sinuosity of <1:1.1 (i.e. it is less sinuous than the upper Meghna), its channel pattern may still be characterized as slightly sinuous with some anastomosing bends, since parts of its main channel divide into several narrower sub-channels which flow around these island chars.

The Meghna Estuary: A Transitional Environment of Unstable Chars

Morphological Characteristics of the Estuary

An estuary is a complex hydrodynamic environment involving interactions of fluvial, marine, and tidal processes. The Meghna estuary is a relatively shallow and wide shelf which descends into a deeper basin beyond its southern end (Ali et al. 2007). The configuration of this estuary resembles an inverted funnel through which the streamflow diffuses southward across the wider part of the shelf. Parts of the huge amounts of sediment load delivered by the combined flow of three rivers (estimated at 1.5–2 billion metric tons per year) have contributed to the construction of some of the larger alluvial islands of the estuary, notably Bhola (an administrative district), Monpura (a part of the Bhola district), and Hatiya. All of these islands have been experiencing extensive bank erosion and simultaneous formation of charlands along their perimeters. In addition to these larger islands, countless numbers of incipient and ephemeral island chars are scattered throughout the estuary.

Hydrodynamic Environment of the Estuary

Despite the exposure of the Meghna estuary to powerful tropical cyclones and storms which induce large waves and storm surges, more persistent fluvial and tidal processes determine the dominant morphological characteristics of the estuary. Marine processes, especially northward flowing longshore transportation of sediments, are pronounced only along the Chittagong coast, i.e., largely beyond the Meghna estuary (Barua 1990). Fluvial processes, on the other hand, dominate the western side of the estuary.

Erosion of Bhola Island: A Geospatial Analysis

The configuration of the Meghna estuary has been evolving with time partly due to erosion of some of the estuarine rivers, resulting in their channel migration. Some of the most unstable rivers of Bangladesh are situated adjacent to the western side of the Meghna Estuary. For example, Char Hijla and Mehendiganj have been experiencing accelerated erosion in recent years due to concentration of the lower Meghna flow along its right bank. The problem has been further exacerbated by the Arial Khan which carries large volumes of the Meghna around these islands (i.e., Char Hijla and Mehendiganj).

Perhaps, the most serious bank erosion problems have threatened the existence of Bhola, the largest island of the Meghna estuary. A comparison of the current Google Earth satellite imagery of Bhola Island with the late 1780s Rennell's map shows very little similarities between the two outlines of the island. Ever since then the island has been evolving its outlines due to the simultaneous processes of bank erosion and sediment accretion (Galib and Moniruzzaman 2017; Islam et al. 2015).

The current analyses are based on three successive historical snapshots of the USGS Landsat imagery of Bhola Island: (a) Landsat 5 TM: 21 February 1989, (b) Landsat 5 TM: 17 February 1999, (c) Landsat 8: 8 March 2019 (USGS 2019). To determine the water-land boundary, we employed the "modified normalized water index (MNDWI)" for each of the sample years. The revised MNDWI is a modification of McFeeter's (1996) original "normalized difference water index." For delineating land and water boundaries, including shoreline configuration, imagery-based water indices are used widely (see, for example, Sagar et al. 2017; Ouma and Tateishi 2006). The MNDWI makes use of the middle infrared (MIR) and the green bands to create an index that improve the capacity to identify open water and non-open water sources. The MNDWI is defined as: (Green-MIR)/(Green + MIR). For the entire year, a total of six bands were used with the derived MNDWI as input data for ISODATA unsupervised classification technique available in the ArcGIS Desktop 10.6 and were specified to have ten output classes. The bands included in the analyses were Blue, Green, Red, NIR, MIR, SWIR, and MNDWI. Based on the primary output of 10-class ISODATA classification by using reclassifying tool available in

ArcGIS, the data were reclassified into two classes, i.e., water and non-water, by using interactive visual inspection matching with the source imagery. Based on the water and non-water classification, contour lines were generated for non-water area for each imagery by using Contour List tool available in the ArcGIS. To smooth the generated contour lines, Smooth Line Tool was used for all of the imagery. Finally, Feature to Polygon tool available in ArcGIS was used for creating polygon shapefile for each year individually. Changes in the outlines of Bhola Island from 1989 to 2019 are shown in Fig. 6.2.

The following is a summary of the satellite imagery-based land area of Bhola Island:

- 1989: 2549 km^2 (984 square miles)
- 2000: 2546 km^2 (983 square miles)
- 2019: 2596 km^2 (1041 square miles).

Some of the previous studies corroborate this data. For example, another recent geospatial analysis found that between 1973 and 2000 Bhola had gained about 15,800 ha (158 km^2, or 61 square miles) (Galib and Moniruzzaman, 2017). This finding may seem to be somewhat surprising, given the widespread reports of bank erosion in Bhola. The results are the objective products of geospatial analyses since the land–water classification systems measure both the current outline of Bhola Island and charlands surrounding the island. For the residents of Bhola who have lost their lands to river erosion, it is no consolation that the land area of Bhola has increased in the last three decades. The newly deposited charlands would require

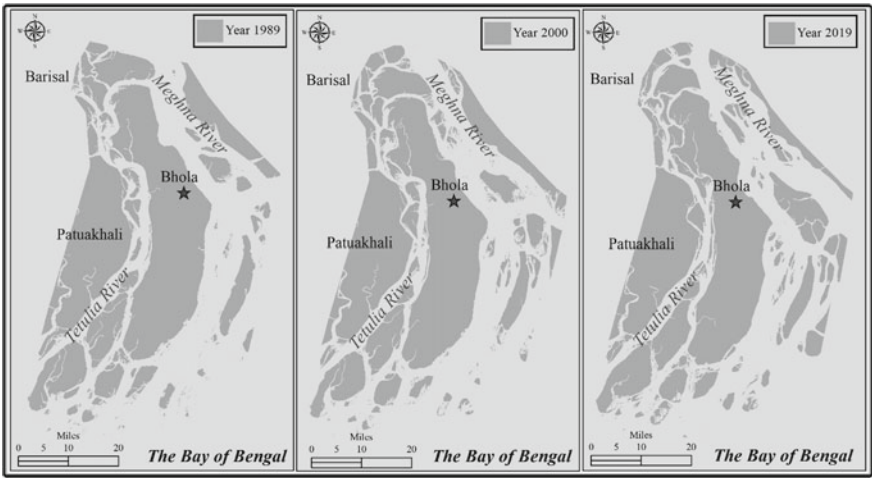

Fig. 6.2 Results of Geospatial Analysis: Erosion of Bhola Island, 1989–2019. *Source* Original figure prepared by Munshi Khaledur Rahman, based on Landsat 5 TM, 21 February 1989, Landsat 5 TM, 17 February 1999 and Landsat 8, 8 March 2019

major engineering reclamation and may take decades for resettlement. Further, there is no guarantee that the reclaimed charlands would not be subject to future erosion in view of the unpredictable morpho-dynamics of the estuary.

Islands and *Chars* of Other Estuaries: A Case Study of Kutubdia Island

Far beyond the hydrodynamic influence of the Meghna estuary, morphological characteristics of Kutubdia and Maheshkhali islands have been shaped by complex interactions between estuarine processes of the Matamuhuri and marine processes of the Bay of Bengal. For several decades, Kutubdia, in particular, has been experiencing extensive bank erosion and accumulation of charlands along their perimeters, displacing coastal residents and affecting their livelihoods (Rahman 2015). As a part of his doctoral research, the second author of the current study employed geospatial analysis to estimate land losses in Kutubdia Island and found that the total area of the island had decreased by about 9 km^2 between 1972 and 2013 (Rahman 2015). The present study is an update of this earlier finding. The methods of geospatial analysis for both Bhola and Kutubdia Island were identical and, therefore, not repeated here. Only the dates of satellite imagery for Kutubdia were slightly different, as follows: (a) 21 February, 1989: Landsat 4 TM, (b) 13 December 2000: Landsat 5 TM, and (c) 1 February 2019: Landsat 8. The results of spatial analysis indicate that the total land area of Kutubdia Island had decreased significantly during the 30-year period of study (Fig. 6.3): 1989: 72 km^2 (28 square miles); 2000: 67 km^2 (26 square miles); and 2019: 62 km^2 (24 square miles).

The latest findings indicate that the total land area of Kutubdia Island had decreased by about 10 km^2 between 1989 and 2019, compared to 9 km^2 between 1972 and 2013. In other words, erosion rates in Kutubdia Island have been accelerating for nearly half a century, from about 0.225 km^2/year (1972–2013) to 0.33 km^2/year (1989–2019). If such erosion rates continue, Kutubdia could be reduced to nearly half of its present size by the end of this century, confirming the alarming headline of the *Guardian*: “Sea Change: The Bay of Bengal’s Vanishing Islands” (Vidal 2013).

From Charlands to Floodplains

The left bank of the upper Meghna provides an example of active floodplain building, starting with the development of large island chars, abandonment of many of these charlands by migrating channels and sub-channels, eventually leading to additional sedimentation and an expansion of floodplains. Major floodplains of Bangladesh have been built similarly by migration of meandering rivers, a process which begins with bank erosion on the concave bank and simultaneous deposition on point bars

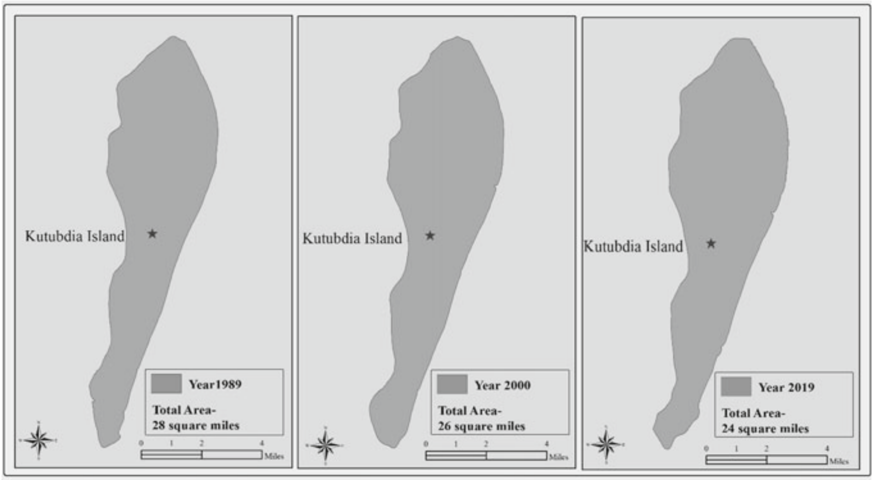

Fig. 6.3 Results of geospatial analysis: erosion of Kutubdia Island, 1989–2019. *Source* Original figure prepared by Munshi Khaledur Rahman, based on Landsat 4 TM, 21 February 1989, Landsat 5 TM, 13 December 2000, and Landsat 8, 1 February 2019

along the convex bank. When this process is repeated over a long period of time (decades and centuries), successive deposition of sediments on point bars results in the formation and growth of floodplains (Leopold et al. 1964, Fig. 7-54, pages 324–325). Field evidence shows that most of the large floodplains, such as the Mississippi floodplains in USA and the Ganges floodplains in India, have been constructed by lateral channel migration, although over-bank deposition during floods complements the process (Rizvi 1955). One of the outcomes of progressive channel migration is that the migrating channels leave behind many abandoned channel features which provide clues to their former geographical positions.

During the reconnaissance of major riverbank erosion and deposition problems in Bangladesh, using the Google Earth satellite imagery, one important observation was that major floodplain surfaces of Bangladesh are replete with countless numbers of morphological features which are associated with abandoned meandering rivers.

Conclusion

It has been demonstrated throughout this study that shorter-term bank erosion, subsequent or simultaneous accumulation of sediments as charlands and longer-term formation of floodplains constitute a continuum of morphological instabilities in alluvial channels of the Bengal delta. People living on the charlands of Bangladesh have long been trying to adapt to the morphological instabilities mentioned above.

Attempts have been taken in the past and more will be there in future to reduce vulnerability of bank lines to problems of erosion. However, these attempts are mainly limited to protecting the mainland. The vast majority of the chars, particularly the island chars, will continue to remain vulnerable to erosion and flooding. It is true that char dwellers have tried their best to cope with these natural calamities. However, they need external support to strengthen their resilience in their pursuit of a better life supported by worthwhile livelihood options. This can be possible only through formulation and implementation of a concerted and integrated char development program in Bangladesh by relevant agencies and institutions.

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Chapter 7
Application of Remote Sensing to Study the Behavior and Dynamics of Riverine and Coastal Chars

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Abstract Bangladesh occupies a major part of the Bengal Delta which has an area in excess of 100,000 m^2. The river systems that build up the delta are very dynamic in nature and govern the lives, livelihoods, and safety of the inhabitants of riverine chars and coastal islands/chars. To study the dynamics of these systems, traditional spatial data such as topographic, bathymetric, and hydrographic surveys are sparse in terms of both spatial and temporal coverage. Over the last four decades, the use of remotely sensed satellite images has proven to be effective in studying the dynamic systems. This paper shows how the analysis of satellite images supports the generation of relevant information and knowledge about both static and dynamic systems. It describes the processing and analyses of the satellite images and their corresponding outcomes. A single image can provide static information such as river bankline, width, braiding index, and char and island geometry. However, a time series of satellite images can provide information and understanding of the dynamics of the system such as erosion and accretion of rivers, chars, estuary and coastal islands, stability of chars and islands, widening and narrowing of rivers.

Keywords Remote sensing · Riverine chars · Coastal islands · Bengal Delta

Background and Objectives

As chars are an integral part of the river, characteristics of chars depend on the river which it belongs to. The Jamuna, Ganges, Padma, and Meghna are large, complex, and dynamic rivers and so are the chars within these rivers. As such it is very difficult to study the behavior of these river systems in terms of river bank erosion, planform change, etc., using traditional means such as aerial photographs, cross-sectional profiles, and bathymetric surveys. Collecting data through these traditional means is

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very expensive and time-consuming. The frequency at which the data can, in practice, be made available for use also poses a hindrance to the study of such dynamic systems. Even during the span of one year, migration of river bank and char boundary, and shifting of the braided channels in these rivers is very high, resulting in changes at the scale of several hundreds of meters. Changes of the river beds also occur at a very high rate within a few weeks to months (Coleman 1969).

The use of remote sensing tools has opened up new possibilities in analyzing the great rivers. While river surveys can take weeks, satellite imagery provides the advantage of a snapshot of the whole system practically at any given time. The repetition of these snapshots allows to track changes of the whole river system over weeks or months. This has made comprehensive morphological analysis and the development of morphological prediction possible. In addition satellite imagery is very inexpensive compared to aerial photography or traditional surveys. Furthermore, analyzing the different bands satellite image, additional information can be gathered, for example, land-use and land-use changes over time as well as cropping patterns. While the latter requires ground truthing (field verification), once this is done large areas can be reliably analyzed allowing the establishment of basic socioeconomic parameters.

The objective of this chapter is to provide an overview of the remote sensing tools for the analysis of river and coastal processes. Remote sensing technology has had a profound impact on the understanding and analyses of the river, riverine chars, estuaries and coastal islands, thereby demonstrating the advantage of this technology over traditional methods of data collection and analyses. The chapter presents selected techniques and some key findings from relevant studies so that future endeavors can benefit from the experience.

Overview of Remote Sensing Applications in the Study of River and Char Behavior

Remotely sensed satellite images was made publicly available in the early 1970s. Prior to that Coleman (1969) carried out a comprehensive study on the morphological processes of the Jamuna River using remotely sensed aerial photographs. Coleman's study introduced the Brahmaputra Jamuna River to the international scientific community. Charles Bristow carried out a PhD research on the Jamuna River using satellite images (Bristow 1987). Subsequently, starting with the Jamuna Bangabandhu Bridge study in the mid-1980s to the early 1990s, several components of the Flood Action Plan (FAP 1, FAP 16, FAP 1, FAP 24) and the Meghna Estuary Study (MES I 2001) addressed the morphological characteristics of the rivers and the Meghna Estuary with the help of satellite images. Results of these studies were published in the several reports, conference proceedings, and journals such as Klaassen et al. (1993), Mosselman et al (1995), and Thorne et al. (1993, 1995).

ISPAN (1995) conducted a pioneering study on the physical processes of the charlands of the Jamuna, Ganges, Padma, and Meghna rivers using time-series satellite images. On the other hand, Thorne et al. (1993) studied riverbank migration of the Jamuna River by comparing national survey maps and aerial photographs from the 1950s, with SPOT images of 1989.

One of the most comprehensive studies on river morphology was carried out by EGIS I (1997), which illustrated the potentials of using satellite images in studying a river as dynamic as the Jamuna. One of the important and critical parameters in studying morphology of dynamic braided rivers is the delineation of the river's bankline. The criteria for delineating banklines of the Jamuna River were developed by EGIS (1997) and Hassan et al. (1997). EGIS II (2000) and Sarker et al. (2003) updated the study of ISPAN (1995) on charlands. During the first two decades of this century, there were a number of research publications on this subject in journals and study reports such as Takagi et al. (2007) and Dewan et al. (2016).

During this period CEGIS and its team of professionals working under the morphology, remote sensing and GIS divisions developed a new specialization in river sciences, which focused on the morphological processes of dynamic river and coastal systems using remote sensing data. A rich archive consisting of time series of historical maps, aerial photographs, and satellite images was developed. They developed sand wave theory (Sarker and Thorne 2006, 2009), methods of predicting river bank erosion, sediment dispersion processes in the Meghna Estuary (MES 2001), a process-response model for assessing morphological response of the Jamuna, Padma, and Meghna rivers to sediment slug, a process-response model for the rivers in the subsiding Sylhet Basin, morpho-dynamic process of the Jamuna River (Sarker et al. 2013). They also developed several tools and techniques for studying the morphological processes of different types of rivers. Methodologies were developed for analyzing morphological processes at various different spatial and temporal scales which proved to be effective for both rivers and the estuary as is demonstrated in Chaps. 8 and 9.

Remote Sensing and Its Utility in Understanding Char Dynamics

In general, the term *remote sensing* refers to data collected from a distance without physically interacting with objects or phenomena of interest. In the field of earth science, the term has a specific connotation that deals with "aerial" and "space-borne" imaging systems used to remotely sense electromagnetic radiation reflected and emitted from the earth's surface. Aerial imaging systems are sensors attached to aircrafts that are flown on demand; i.e., their data capture is not continuous. The data is used to produce "aerial photographs." Space-borne remote sensing uses sensors attached to satellite systems that are continually orbiting around the earth and collecting data to produce "satellite images". While early remote sensing was based on aerial photographs, most of recent remote sensing consists of satellite imagery. Since the launch of the first remote sensing satellite, Sputnik, in 1957, numerous satellites have been launched and the technology is developing at a tremendous pace. Recent developments in "drone" technology which uses unmanned aerial vehicles (UAV) to generate images of the earth's surface has created a new platform for remote sensing.

Most of the studies mentioned above have used images from the following satellites: Landsat 1–8 (with scanners: MSS-Multispectral Scanner, TM-Thematic Mapper or ETM+ -Enhanced Thematic Mapper), IRS-1D and IRS-P6 satellites (with scanner: LISS III-Linear Imaging Self Scanner III). These scanners use sensors that sense solar radiation reflected from the earth's surface in multiple spectral bands within the optical portion of the electromagnetic spectrum creating "multispectral images" which provide a wealth of information in terms of brightness and spectral reflectance of the water, sand, soils, and vegetation of the chars and the rivers. The band combination commonly used is the near-infrared false color composite, consisting of the near infrared, red and green bands which help identify landcovers such as dry sand, wet sand, silt, clear/turbid water, various types of vegetation of the chars, etc. The spatial resolution of the images ranges from 24 to 80 m.

This section demonstrates how these satellite images help in understanding the dynamics of riverine chars and coastal islands. Figure 7.1 shows a time series of multispectral satellite images dated 1997–2004 of the Jamuna River and its chars.

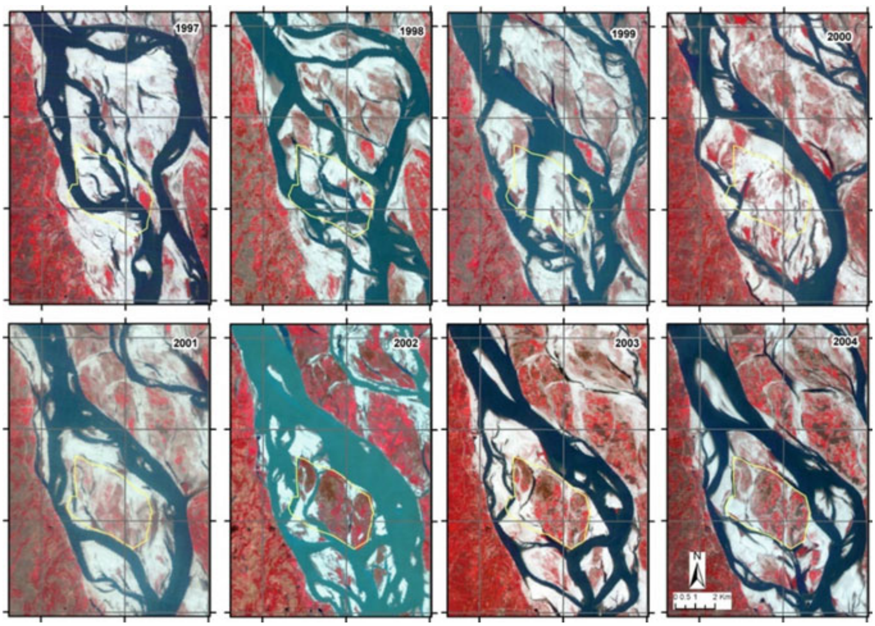


Fig. 7.1 Development of a cluster of bars in the Jamuna River into a char over. *Source* CEGIS (2013)

Roughly, the colors in the images can be interpreted as follow: black and dark blue represent water, white represents sand, and reddish hues represent vegetation. The tremendous changes that have occurred in the river channels are quite obvious from Fig. 7.1. The boundary of a vegetated char observed in the image of 2004 and superimposed on a time series of satellite images starting from 1997 shows the complex char formation process. The boundary in 1997 included the downstream part of a cluster of chars, a reach of a channel and the upstream part of an attached char. In the following two years, there were joining, separating, and rejoining of bars, while abandonment and development of channels took place.

A large and apparently monolithic char emerged in 2000. This char was again separated and rejoined by a braided channel. This complex process of char development has pronounced effects on the lateral and vertical growth and vegetation pattern of the chars.

Similarly, Fig. 7.2 shows the development of Urir Char, a coastal char in the Meghna Estuary, from 1973 to 2001. In the early 1970s, Urir Char was a small land

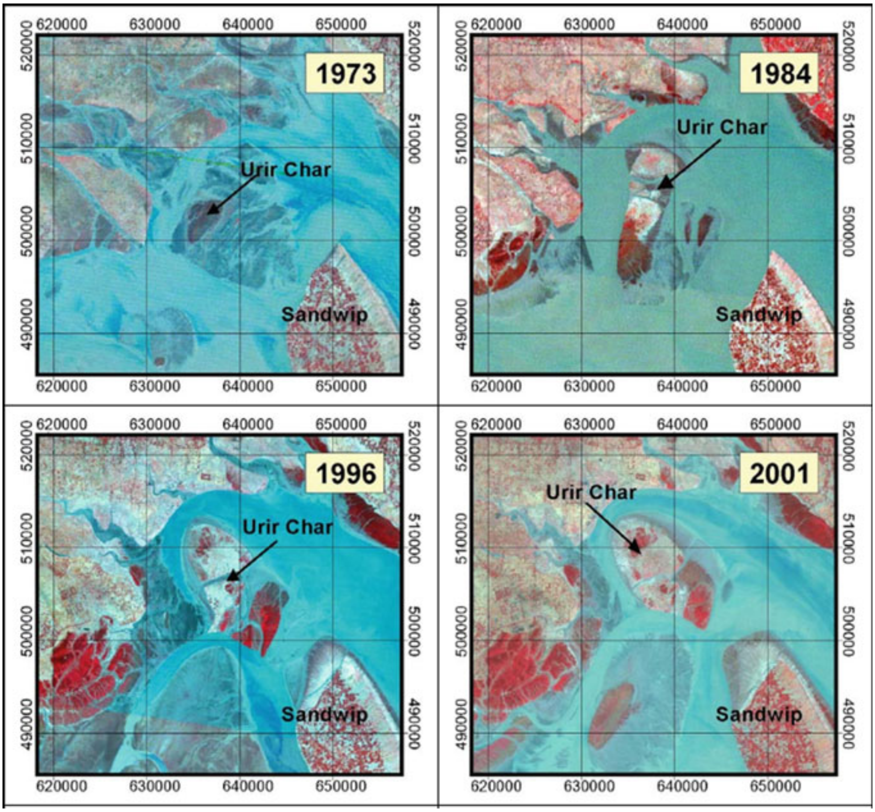


Fig. 7.2 Development of Urir Char and surrounding areas in the Meghna Estuary. *Source* CEGIS (2009a)

situated in the northwest of Sandwip having an area of about 12 km^2. In the next decade, this landmass extended in the north–south direction and three adjacent islands having an area about 64 km^2 emerged as Urir Char in 1984. In 1996, the southern landmass was eroded and extended 70 km^2 eastward. In the early part of this decade, Urir Char appeared as a single landmass with an area of about 85 km^2. This kind of observation has been made possible by the fact that satellites are continuously collecting data of the earth's surface making images available at regular intervals.

Methodology

This section presents some critical issues that needed to be considered and important steps that were to be taken for acquiring, processing and analyzing satellite image data to study the behavior of the rivers and estuaries and subsequent dynamic behavior of chars and islands. The methodology is based on the experience of ISPAN, EGIS, and CEGIS in developing a large time series of images of the Jamuna, Ganges, Padma, and Lower Meghna rivers dating from 1973 to 2020.

The basic steps include selecting and procuring the images, georeferencing, and classification, delineating banklines/shorelines, estimating width and braiding intensity of the rivers, size and shape of char/island. Figure 7.3 illustrates the steps and the outcome of each step. The first four steps yield static characteristics of riverine chars, estuary and islands. Adding time-series data yields new information such as change in land use, bankline or shoreline erosion/accretion, widening, narrowing, and changes in braiding intensity i.e., the dynamic characteristics of rivers and chars. Changes in the river affect the behavior of riverine chars, and similarly, changes in estuary have profound effects on the coastal islands. To explain the physical processes of rivers, chars, estuaries and coastal islands using time-series satellite images, several studies and research projects have been carried out by FAP studies and later on by CEGIS during the last three decades. Some of those are documented in Chaps. 8 and 9 of this book.

Processing and Analyzing Satellite Images

Selection of Images

In selecting a time period for image acquisition for morphology studies, several factors need to be kept in mind: (i) The image needs to be acquired at a time when the study area is almost cloud-free because "optical" scanners cannot image the earth surface through cloud cover, (ii) the river's water level should be low on the imaging date because images acquired at a time of low water level exhibit the alignment and width of the main channels that cause the large-scale morphological and planform

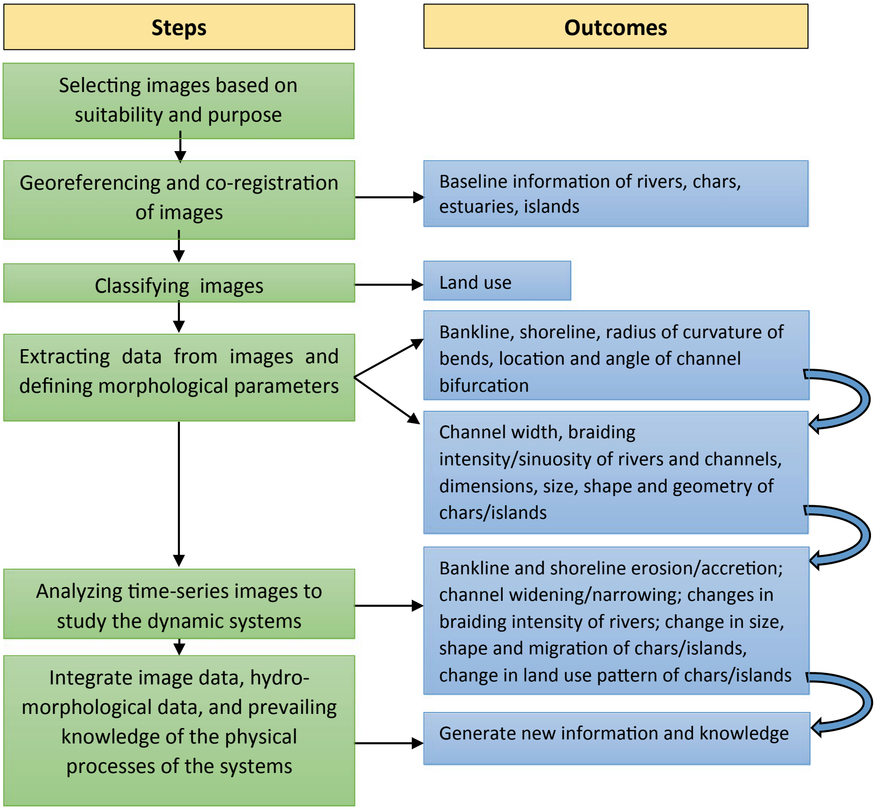


Fig. 7.3 Flowchart showing steps in the processing and analyses of satellite images for studying morphology of rivers, riverine chars, estuaries and islands, and outcomes corresponding to each step

changes, (iii) to allow comparison between consecutive images, it is important that the river stage or water level in each image is approximately the same.

Bangladesh has considerable cloud cover throughout the year. In the months of December and January, the monthly average cloud-cover is lowest, i.e., less than 1 okta on a scale of 0–8 (where 0 okta means “completely clear sky” and 8 okta means “completely overcast”) (Hossain 2015). It gradually rises to a peak 6 okta in July. Water levels are low, for example, in the Jamuna River’s Bahadurabad station during the period from January to March, with the lowest in February as per representative hydrographs of the station. An image of February would be ideal for the Jamuna River provided the study area is cloud-free. However, the satellites of interest have their own fixed repeat cycle, for example, Landsat 8 can image an area once every 16 days and IRS—P6 LISS III once every 24 days. This means there would be only one or two satellite overpasses in February, and if those do not yield a cloud-free

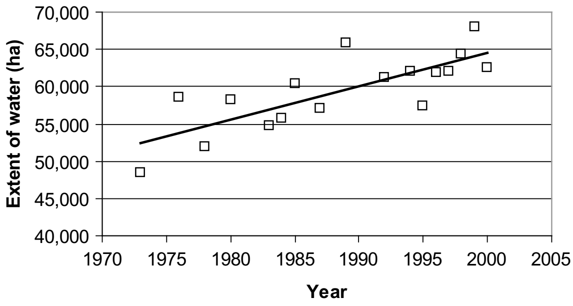


Fig. 7.4 Change in water surface area derived from time series of satellite images with time. *Source* Sarker and Thorne (2009)

image, then images of other dates would have to be used when the water levels may be higher than desired.

EGIS (1997) investigated the effect of water level variations on water surface area in the images to ensure that morphological interpretations were not substantially affected. A regression was run for water levels at the Bahadurabad station against total water area as determined from the satellite image classification for 13 image dates. The regression analysis showed that for a range of water level of about 1 m, the corresponding range of total water surface area is about 10,000 ha. On the other hand, Sarker and Thorne (2009) analyzed 18 images (Fig. 7.4) and found a trend of increase in water surface area with time. The discussions above suggest that time-series analyses of rivers and chars should use images taken with corresponding water levels. However, ideal conditions cannot always be met because of constraints of cloud cover, availability, and data quality; therefore, analysis and interpretation should always attempt to account for these variations.

Georeferencing and Co-registration

Each image has to go through "georeferencing" which associates it with a spatial location and relates the image pixels to a ground system of geographic coordinates that follows a projection system. All images used for multi-temporal analysis must also be "co-registered" to ensure that they spatially correspond with one another. Specialized image processing software would be required to perform this function.

Image Classification

To study river morphology and char dynamics, the images have to be "classified" into landcover classes that are relevant for identifying landcover within the river banklines. Most studies of the rivers and chars need to identify three or four broad landcover classes in the rivers, chars, and floodplains. The three main classes are

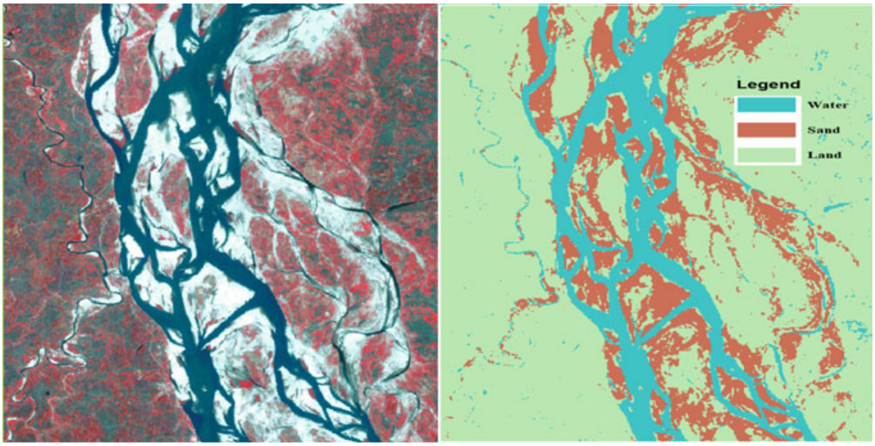


Fig. 7.5 A satellite image and a classified image of a reach of the Jamuna River. *Source* CEGIS

water, sand, and land (Fig. 7.5). The classified images are the main source of data to study char dynamic.

Classification involves applying image processing techniques to assign landcover classes to areas in the image with similar spectral characteristics. Accuracy of image classification is a particularly important factor for multitemporal image analysis. "Ground truth" field surveys are carried out approximately around image date to collect field data on landcover type which is compared to the classified images to assess classification accuracy. For the image dataset of the Jamuna River and Chars, the most extensive field assessment was carried out in 1992, as described in ISPAN (1995) involving several visits to the Jamuna River where fluvial processes, landcover, and agronomic practices were observed and the ground truth data documented. Two hundred and forty-five sites along the entire course of the river within Bangladesh were covered. An overall classification accuracy of 88 percent was found for three broad landcover classes: water, sand, and land.

Defining Morphological Parameters and Extracting Data from Images

Delineating River Banklines

The bankline is a very basic data required to study river morphology. It is used to analyze and predict bank erosion and accretion as well as changes in river width. Delineation of the banklines of a braided river from a satellite image is not a straight forward task. It is easy to delineate the bankline along an eroding bank, but the presence of attached islands and marginal sub-channels often makes it difficult to

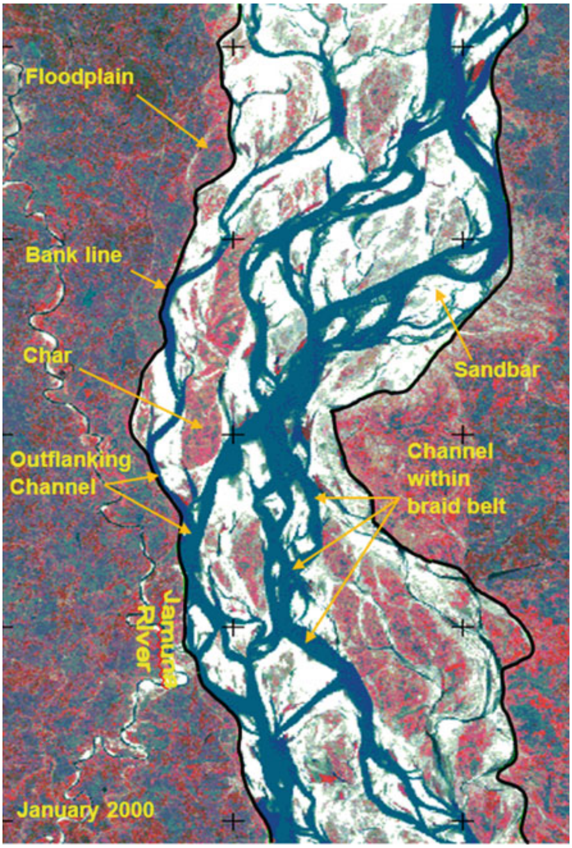


Fig. 7.6 Satellite image of Jamuna River showing various planform features—channels, chars, sand bars and banklines. *Source* EGIS (2002)

delineate it in a consistent manner. The bankline (Fig. 7.6) is defined as the line that separates the floodplain from the river channel. The channel of a braided river includes channels and chars (sand bars and vegetated islands) within the braid belt.

Where a large anabranch channel within the braided river flows along the edge of the floodplain (typically ranging in width from a few hundred meters to several kilometers in the case of the Jamuna), bankline delineation is simple and uncontroversial. However, where smaller sub-channels flow next to the bank, the sub-channel width, length, flow direction, and meandering characteristics must be considered when deciding whether to include it within the bankline or treat it as a channel formed in the floodplain.

The Environment and GIS Support Project (EGIS) developed criteria for delineating banklines of the Jamuna River using Landsat MSS (80 m $\times$ 80 m) and TM (30 m $\times$ 30 m) images (EGIS 1997; Hassan et al. 1997). A team of consultants and experts from the EGIS project and Bangladesh University of Engineering and Technology (BUET) defined bankline delineation criteria for the Jamuna River to ensure consistent interpretation. The same criteria are applied for the banklines of the Padma and Lower Meghna rivers. Based on these criteria, banklines are digitized in a GIS environment using satellite images as backdrop on a computer screen, as shown in Fig. 7.6.

Delineating the Shoreline

Like the rivers and chars in the Jamuna, Padma, and Lower Meghna rivers, islands in the coastal area, especially in the Meghna Estuary are very dynamic. To study the dynamic system, delineation of the shoreline on time-series satellite images is crucial. Dolan et al. (1980) defined shoreline as a line which coincides with the physical interface of land and water. Although its definition is simple, in practice it is a challenge to apply. The position of the shoreline changes continuously due to cross-shore and along-shore sediment transport and especially due to the continuous variation of water level with the tide at the coastal boundary (Boak and Turner 2005). The extent of intertidal areas varies from few tens of meter per year to few hundreds of meters per year.

To nullify the effect of tidal variation, a method of delineating the shoreline from satellite images was developed by CEGIS (2009a). The shoreline delineated on the image of 2008 is shown in Fig. 7.7. The boundary of vegetation as visible in optical images is considered as shoreline. Errors in the delineation of the shorelines were also introduced by the pixel size of the images and the presence of a wide intertidal flat. Error in delineating shoreline at wide intertidal areas is high compared to the errors associated with delineating banklines of the rivers. Because of the high uncertainty involved in delineating the shoreline, it is recommended that the time interval between consecutive images in a time series to analyze changes in the shoreline or coastal chars in terms of erosion and accretion should be higher than one year.

Estimating River Width

Width is a fundamental feature of the river and an indicator of morphological dynamics. River width is usually defined as the shortest distance between the right and left banks. However, as the Jamuna River is aligned almost due north–south, EGIS (1997) determined the width of the Jamuna River along east–west transects spaced at 500 m intervals, by subtracting the easting of the right bank from that of the left bank (Fig. 7.8). To determine the width of the Padma and Lower Meghna rivers, the average alignment of the rivers was determined first using the time-series banklines (Sarker and Thorne 2009) extracted from the images. Cross-lines perpendicular to the average alignment were then drawn to dissect the banklines. The area within the banks and two consecutive transects was divided by the length of the river reach along the alignment to yield the reach averaged width of the river (Fig. 7.9).

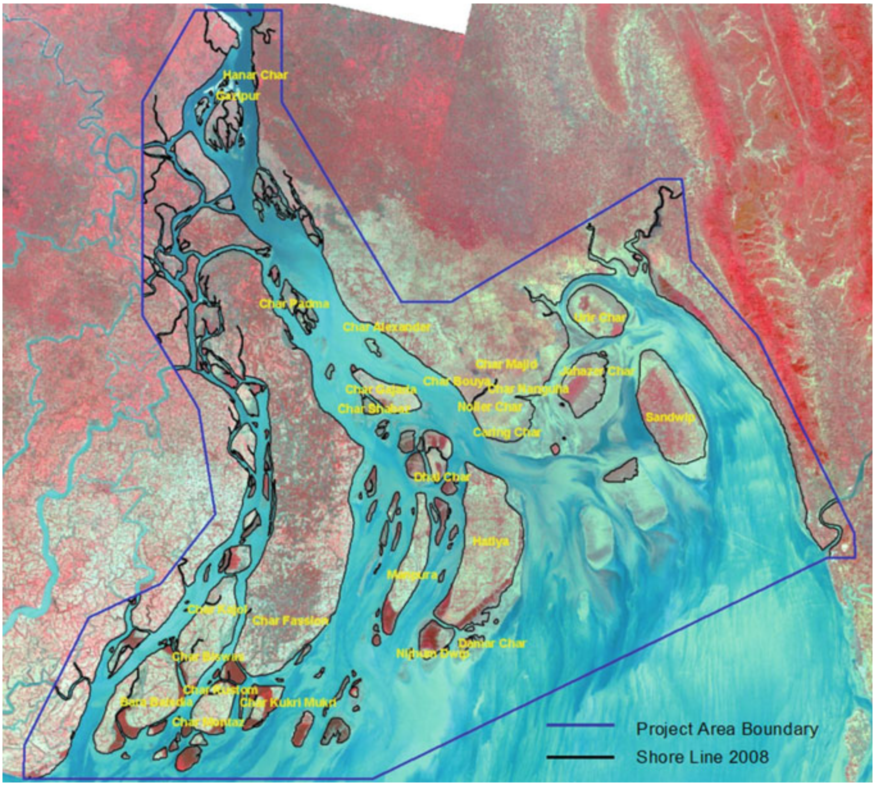


Fig. 7.7 Shoreline of Bangladesh delineated from IRS P6 LISS III satellite image mosaic, 2008. *Source* CEGIS (2009a)

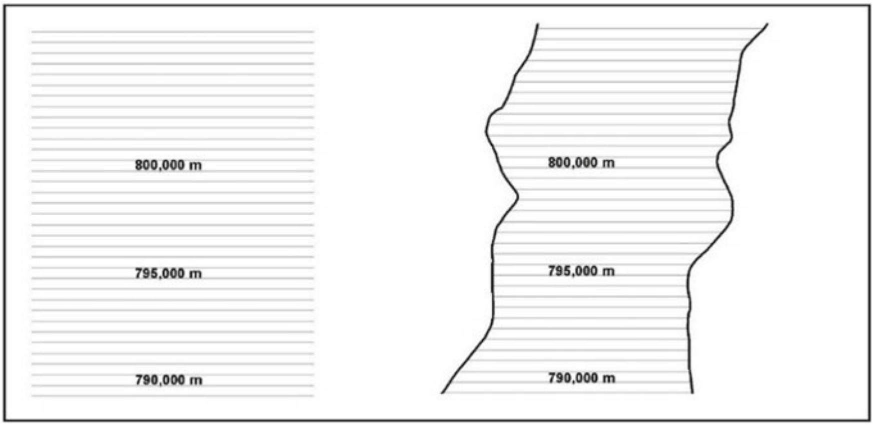


Fig. 7.8 Method of estimating the width of Jamuna River. *Source* EGIS (1997)

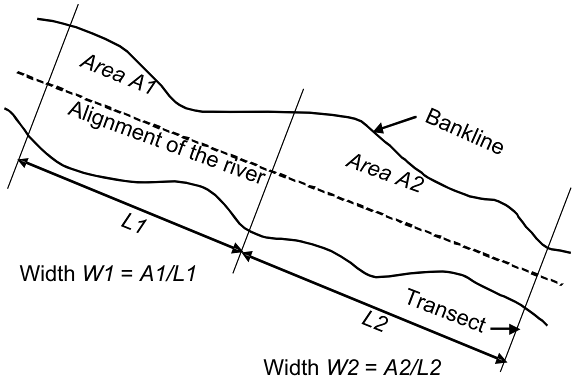


Fig. 7.9 Method of estimating reach averaged width of Padma and Lower Meghna rivers. *Source* Sarker and Thorne (2009)

Radius of Curvature of Bends

River bank erosion occurs along the outer bend of meandering rivers which is a curved channel. In the case of braided rivers, bank erosion occurs along the outer bend of flanking channels. The rate of bank erosion depends on several factors, among which radius of curvature is an influential factors. Radius of curvature is the reciprocal of the curvature as extracted from satellite images. For a curve, it equals the radius of the circular arc which best approximates the curve at that point (Fig. 7.10).

Bifurcations and confluences of secondary channels (Bristow 1987) are very common features in the Jamuna River. These secondary channels are the dominant channels in a braided section of the river. According to Bristow, the primary channel of the Jamuna River consists of all the secondary channels in a section of the river; i.e., it is the whole channel within the banks. In a bifurcation, two channels emerge from a single channel upstream of the bifurcation. *Deviation angles* are the

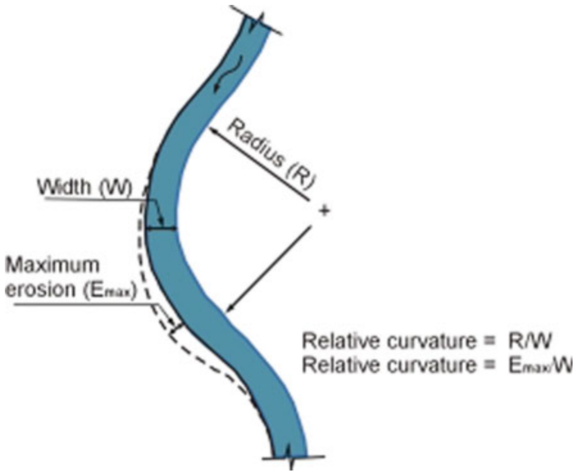


Fig. 7.10 Illustration of relative maximum bank erosion and relative radius of curvature extracted from satellite image. *Source* EGIS (2002)

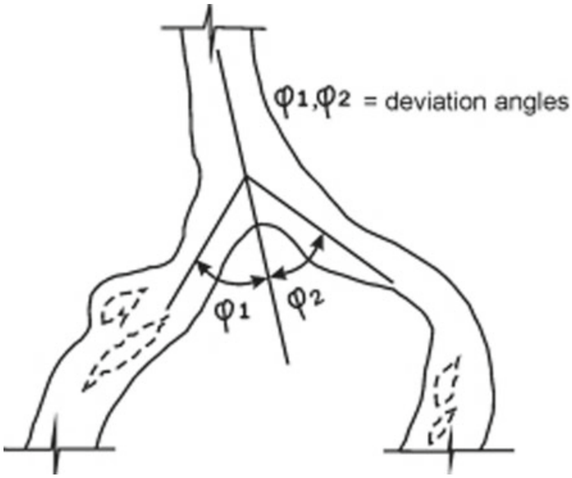


Fig. 7.11 Illustration of deviation angles extracted from satellite image. *Source* EGIS (2002)

angles between the alignment of the upstream channel and the bifurcating channels (Fig. 7.11). Prediction of the abandonment of the braided channel depends on the deviation angle, and it is a component of riverbank erosion. Channel alignments, both upstream and downstream bifurcating channels and their deviation angles, are all measured from satellite images.

Braiding Intensity

The intensity of braiding is an important morphological parameter in rivers with multi-threaded channels, and it is related to the formation and destruction of chars. Braiding intensity defines the stability of the chars: Higher braiding intensity is associated with lower char stability (Sarker and Thorne 2009).

Klaassen and Vermeer (1988), Halcrow et al. (1994), EGIS (1997) and Sarker and Thorne (2009) have all studied braiding intensity of the Jamuna River using time-series satellite images. They estimated braiding intensity following the method suggested by Howard et al. (1970). A braiding index is measured as the average number of anabranches bisected by transects at each end and the center of a reach (Howard et al. 1970).

Analysis of Time-Series Images to Study the Dynamic Systems

Processing and analysis of a single image provide static information. To study the dynamics of any physical process such as shifting of river and riverine chars, delta building in the estuary, river bank erosion/accretion, river narrowing/widening, age of chars requires time-series satellite images. Char dynamics is closely related to the morphological behavior of a river as a whole, and in particular to the bank erosion processes and the trends of widening and narrowing of rivers (Sarker and Thorne 2006, 2009). Widening of the rivers generally increases the char area. During development, a char may form as an island char or an attached char and it may grow, migrate, and disappear within a few years. Island chars are surrounded by water year-round and attached chars are connected to the mainland under normal flow conditions. It has been found that the initiation of char growth is related with riverbank/char erosion in the upstream while lateral growth of the chars also causes the riverbanks to erode (Sarker and Thorne 2006, 2009). Multitemporal satellite images provide an opportunity to study some of the major river processes that drive the development, disintegration, and stability of chars.

River Erosion and Accretion

Amount and location of bank erosion between two dates can be determined by superimposing the banklines derived from satellite images of the two dates (Fig. 7.12). Based on lateral extent of riverbank erosion and spatial resolution of the satellite images, the appropriate time interval for erosion mapping should be determined. It has been found that for the case of Jamuna, Padma, and Lower Meghna rivers, images of 24–30 m resolution can be used to map and calculate yearly riverbank erosion (Fig. 7.13).

As shown in the map (Fig. 7.12) derived by superimposing banklines, erosion was the dominating process along the Jamuna bankline from 1973 to 2018 (Sarker and Hore 2020). A large area of floodplain (90,830 ha) was eroded, while only a small area was accreted (10,140 ha). Figure 7.12 shows that the left bank erosion rate was higher compared to the right bank. The annual erosion rate reduced from 5000 ha/year in the 1980s to about 2000 ha/year in the 2000s. The reduction in erosion is attributed partly to natural processes and partly to river bank protection schemes of the mid-1990s (Sarker and Hore 2020).

Erosion and Accretion in the Meghna Estuary

The Meghna Estuary is morphologically very dynamic. Lateral erosion and accretion is in the scale of several thousand hectares per year. Implementation of any development plan requires close monitoring. Erosion and accretion in the Meghna Estuary has been studied by various initiatives working on development of the estuary, e.g., the Land Reclamation Project (LRP), Estuary Development Project (EDP) and Meghna Estuary Studies (MES) of BWDB. They have developed a wealth of knowledge and understanding of the land formation, erosion and accretion in the estuary and the

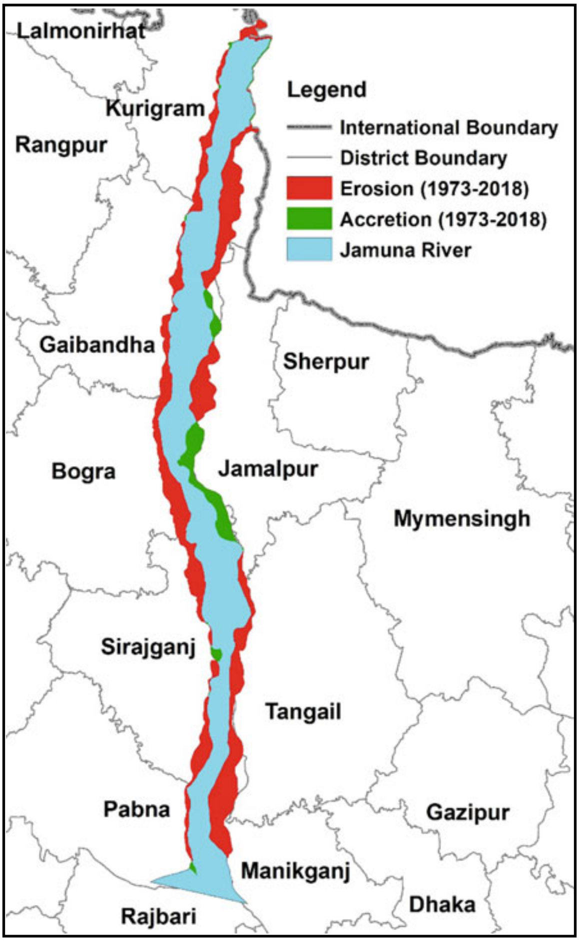


Fig. 7.12 Erosion-accretion along the Jamuna River 1973–2018. *Source* Sarker and Hore (2002)

coastal chars using historical maps and satellite images. Figures 7.14 and 7.15 show the erosion and accretion, and their district-wise distribution as analyzed by Sarker et al. (2011) based on the satellite images of 1973 and 2008.

Net rate of accretion of land was found to be very high in the Noakhali District, followed by Patuakhali and Chittagong. Noakhali District is the most sediment deposition prone area in the Meghna Estuary. In other districts, land erosion is almost balanced by accretion. Analysis of erosion/accretion for smaller time-steps suggests that the net accretion at Patuakhali occurred in a particular period. On the other hand, net accretion dominated in Noakhali District during 1973–2008.

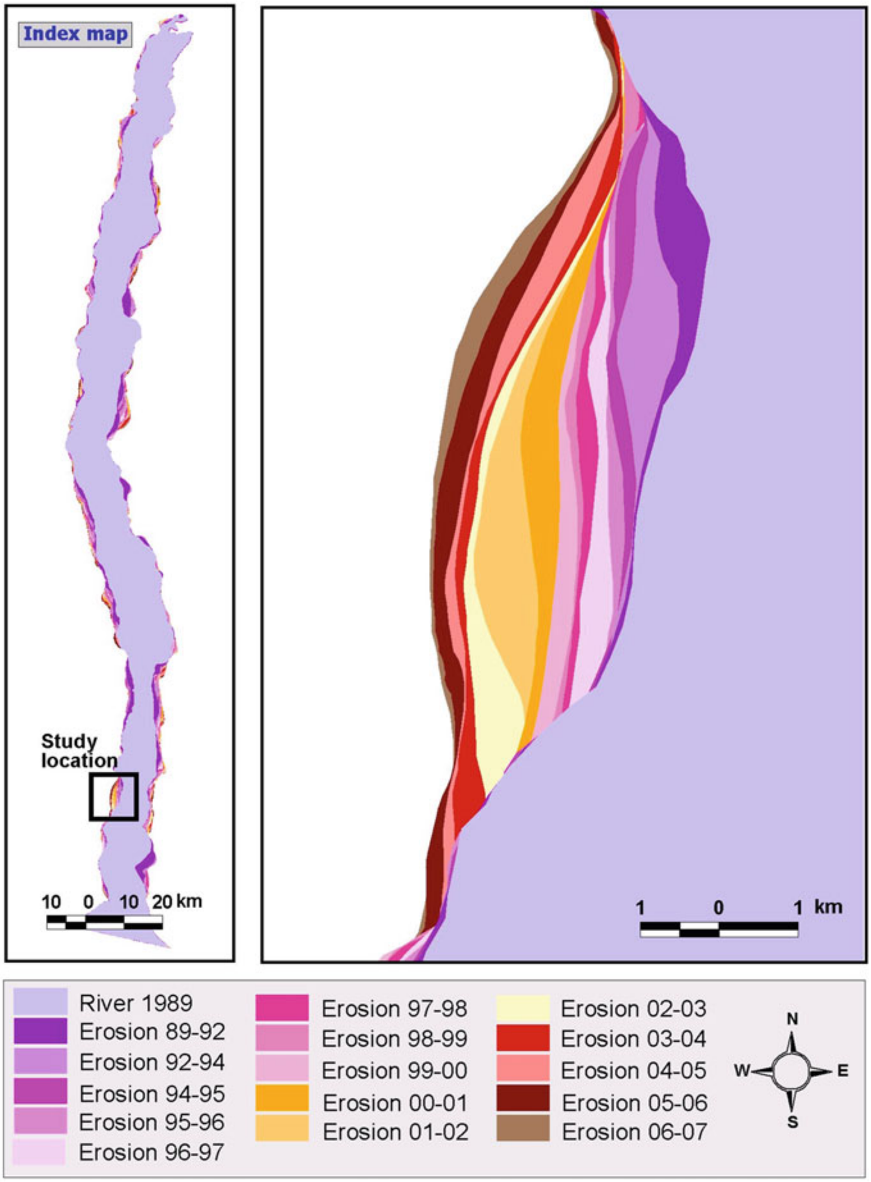


Fig. 7.13 Jamuna River—cumulative erosion. *Source* CEGIS

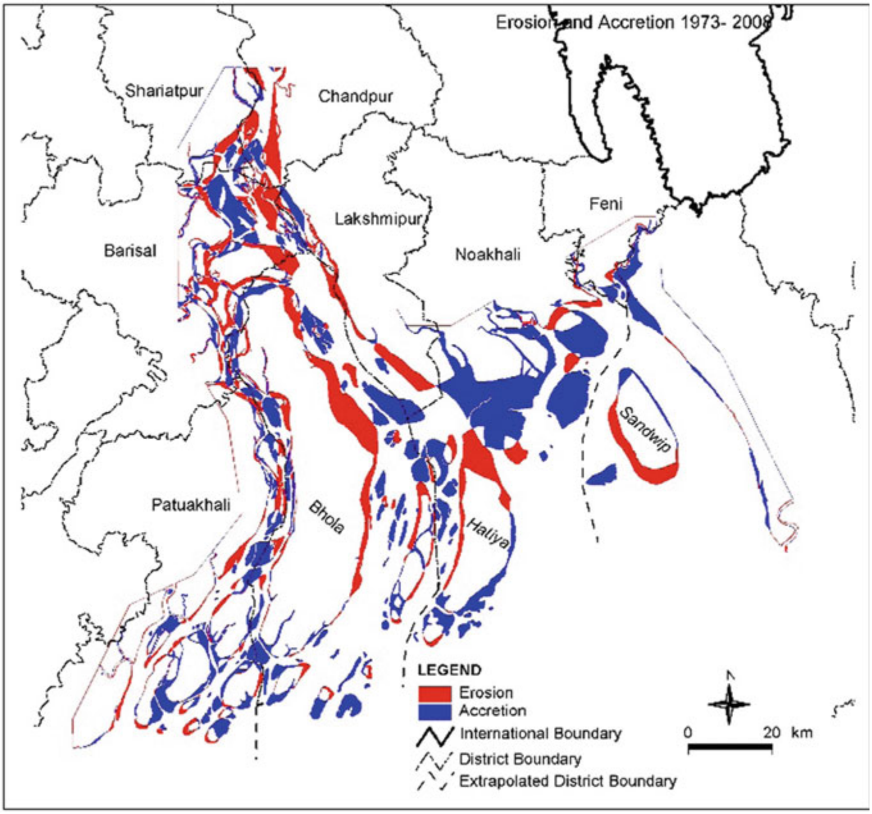


Fig. 7.14 Erosion and accretion in the Meghna Estuary during the period of 1973–2008. *Source* Sarker et al. (2011)

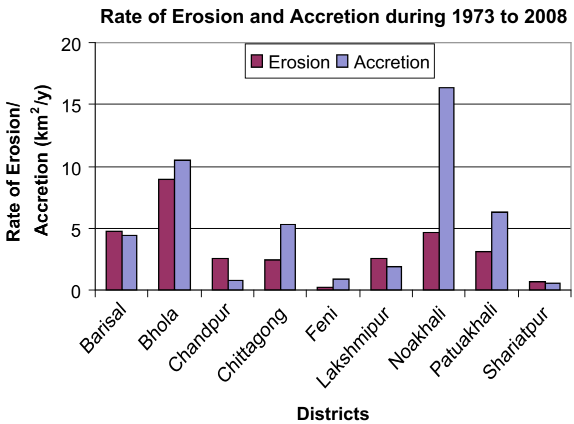


Fig. 7.15 District-wise distribution of erosion and accretion during the period of 1973–2008. *Source* Sarker et al. (2011)

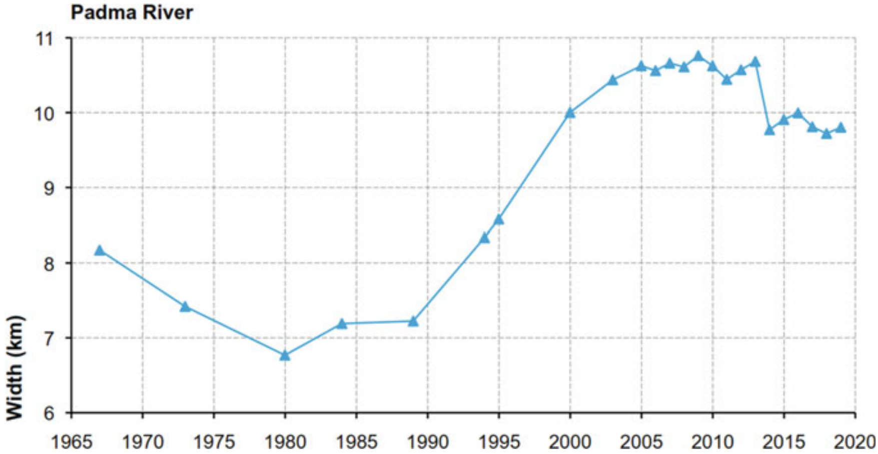


Fig. 7.16 Changes in length averaged width of the Padma River with time. *Source* Sarker and Hore (2020)

Narrowing and Widening of Rivers

The width data derived from time-series images helps understand the rivers' widening and narrowing trends. Figure 7.16 shows the reach averaged width of the Padma River from 1967 to 2019. In this period, the width of the river changed from 6.7 to 10.7 km. The width reduced from 1976 to 1980, but from 1989, it increased steadily up to 2005 after which it became more stable for the period up to 2013. In 2013, there was a sudden drop in width, after which it again somewhat stabilized.

The dramatic increase in width has been attributed to sediment slug generated by huge slides in the Himalayas due to the 1950 Assam Earthquake which affected the entire Brahmaputra–Jamuna–Padma–Lower Meghna river system (Sarker and Thorne 2006). The sediment slug affected the Padma River with a certain time lag.

Changes in Braiding Intensity

To study the changes in braiding intensity over time, Sarker and Thorne (2009) first created a GIS database of channel positions derived from one aerial photograph of 1967 and 16 satellite images of 1973–2004, established channel hierarchies, identified the appropriate sub-reaches for calculating the braiding indices, and performed the necessary measurements to identify the degree of braiding as well as spatial and temporal trends in braiding intensity. Similar analysis was done for Padma and Lower Meghna rivers. The braiding indices after Sarker and Thorne (2009) are shown in Fig. 7.17. The Jamuna River became more and more braided in the 1970s and 1980s reaching a peak in 1992 and reduced afterward. Sarker et al. (2011) showed that

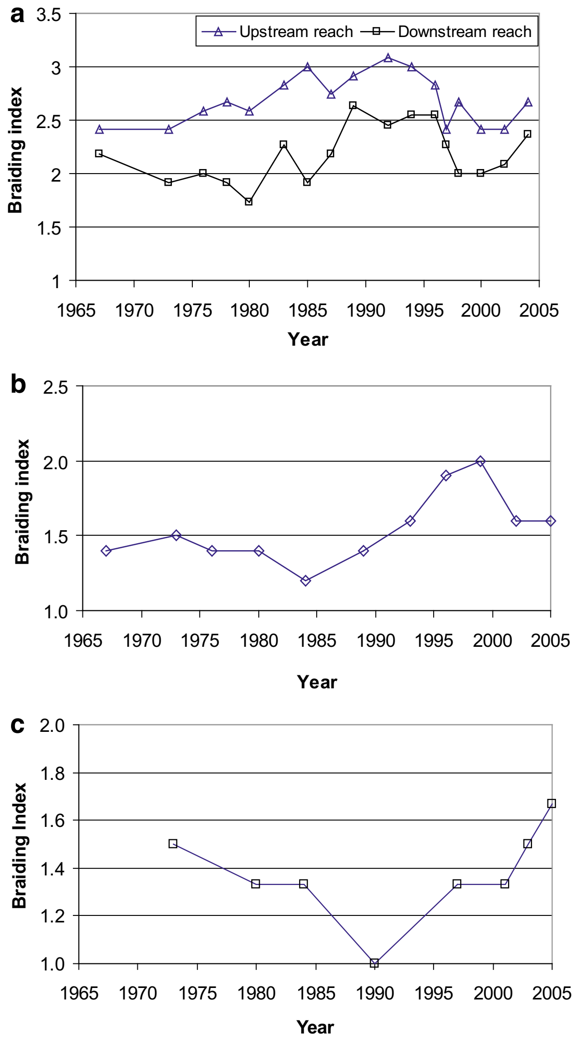


Fig. 7.17 Changes in braiding intensity of **a** Jamuna, **b** Padma, and **c** Lower Meghna rivers. *Source* Sarker and Thorne (2009)

immediately after the construction of the Jamuna Bridge and its river training works (which can be related to the image of 1997), the braiding index of the downstream reach reduced drastically which means the training works stabilized the river downstream of the bridge. This led CEGIS (2013) to infer that properly located bank protection works can stabilize the river over a substantial length without having to stabilize the entire bank. This kind of management support is possible because of availability of a rich archive of satellite images and the knowledge and experience gathered through years of analysis and scrutiny of the image data.

Char Age

Age of chars at any given image date is mapped by superimposing a series of previous years' classified images, each of which show the "water," "sand," and "land" areas of the respective image date. In the char age map of 1992 (ISPAN 1995), it was found that the average age of 38% of the chars was less than 3 years, and 14% of the chars were more than 20 years old. However, in the char age map of 2000, the average age of 56% of the chars was less than 3 years and only 6% were more than 19 years old, indicating that char stability had decreased in the span of 8 years from 1992 to 2000 (EGIS 2000).

The char age maps proved to be instrumental in developing a plan to stabilize the course of the Jamuna and Padma rivers. The Main River Flood and Bank Erosion Risk Management Project (MRP) of the BWDB proposed the plan to stabilize the rivers, which involves protecting the attached chars from future erosion and raising the island chars to flood level.

The plan is informed by an in-depth study (CEGIS 2013) of the natural development of the chars, which generated a great deal of information and knowledge. The study focused on the assessment of vertical accretion and vegetation colonization within a 65 km reach downstream of the Jamuna River, using a combination of image-based char age map (Fig. 7.18), time-series cross-sectional survey data from BWDB, and spot leveling data of three selected chars. Figures 7.19 and 7.20 provide a glimpse of the findings. It was found that the rates of vertical growth of the three selected study chars were very close, and that it took the chars about 8–10 years to reach the average relative elevation of chars (Fig. 7.20). The vertical growth rate was lower than that calculated by a previous study (EGIS 1997) but both studies provide almost the same result of mean relative vertical height of 5.5 m for Jamuna chars. Figure 7.20 shows that whereas newly accreted chars have little vegetation, colonization of vegetation reaches close to a hundred percent after 8 years.

Unlike the riverine chars, stability of the islands in the Meghna Estuary is very high. For example, in Bhola, which is the largest island in the estuary, nearly 50% of the land surface is more than 75 years old (Fig. 7.21). The stability of Sandwip Island is highest among all islands in the Meghna Estuary. Almost 75% of its surface area is more than 242 years old.

River Planform Dynamics

During the detailed design phase of the Padma Bridge study, the entire length of about 100 km long Padma River was divided into three reaches: Faridpur reach, Mawa reach, and Shariatpur reach. Planform of these reaches was found to change over time from straight, to meandering, to braided. Position of the Padma Bridge is in the Mawa reach. Therefore, changes in planform of this reach are crucial for the safety of the bridge.

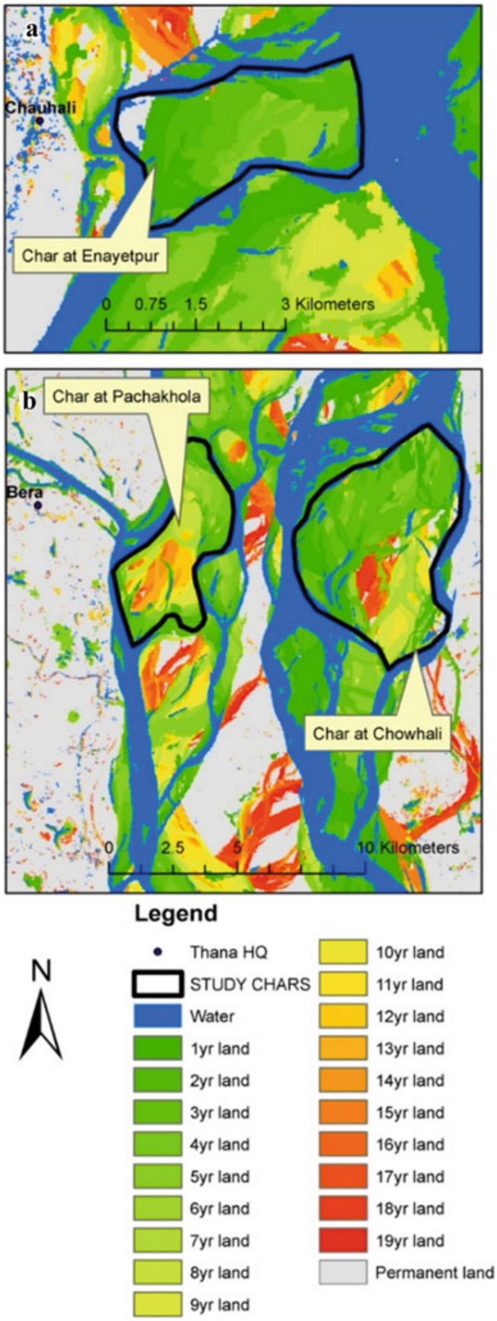


Fig. 7.18 Age of selected chars of the Jamuna River in 2013. *Source* CEGIS (2013)

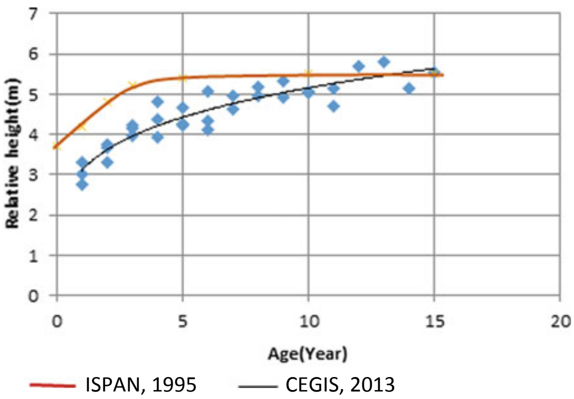


Fig. 7.19 Relation between relative height and age of char from two different studies. *Source* CEGIS (2013)

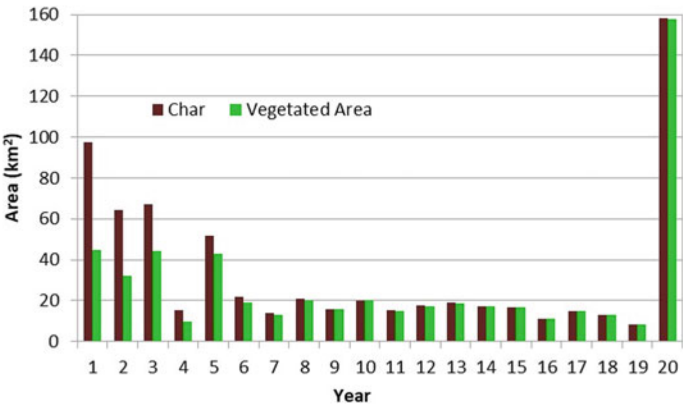
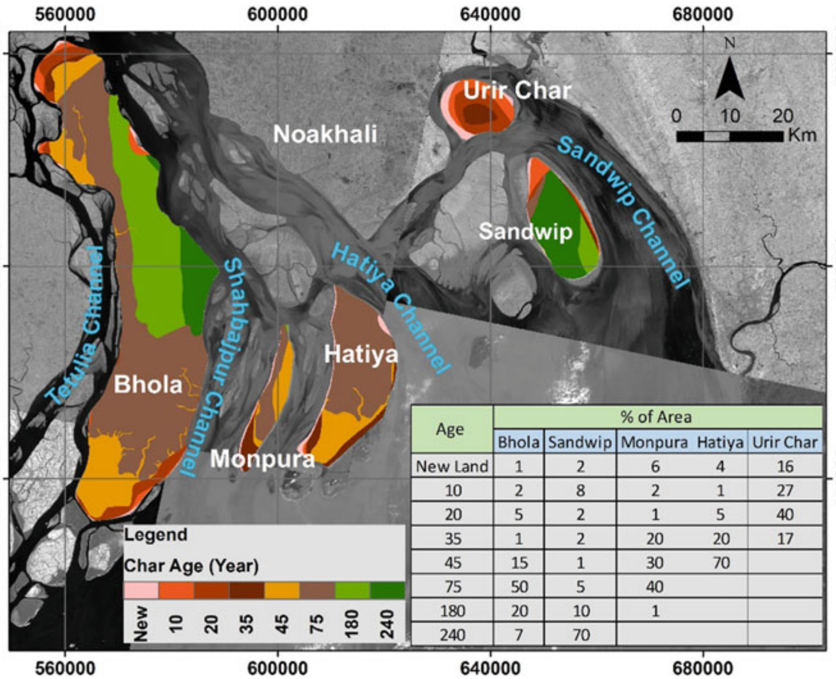


Fig. 7.20 Relation between age of char and vegetated area within the study area. *Source* CEGIS (2013)

To study morphological metamorphosis, three parameters, i.e., straight, meandering, and braided width, were extracted from historical maps and time-series satellite images (CEGIS 2009b). Definition diagram of these parameters is presented in Fig. 7.22. Analysis of time-series data shows the existence of a cyclic behavior, the period of which varies from 25 to 30 years (Fig. 7.23). Identifications of the cyclic behavior facilitated the prediction of the planform developments upstream of the bridge. Planform changes of two other reaches did not demonstrate any kind of cyclicity.



Age	% of Area				
	Bhola	Sandwip	Monpura	Hatiya	Urir Char
New Land	1	2	6	4	16
10	2	8	2	1	27
20	5	2	1	5	40
35	1	2	20	20	17
45	15	1	30	70	
75	50	5	40		
180	20	10	1		
240	7	70			

Fig. 7.21 Age of different parts of the coastal islands of Bhola, Hatiya, Sandwip, Monpura, and Urir char as observed in 2018 satellite images. Age is calculated from Rennell's map (1776), Tassin's map (1840), topographic map (1943), and satellite images of 1973, 1984, 1998, 2008. *Source* CEGIS

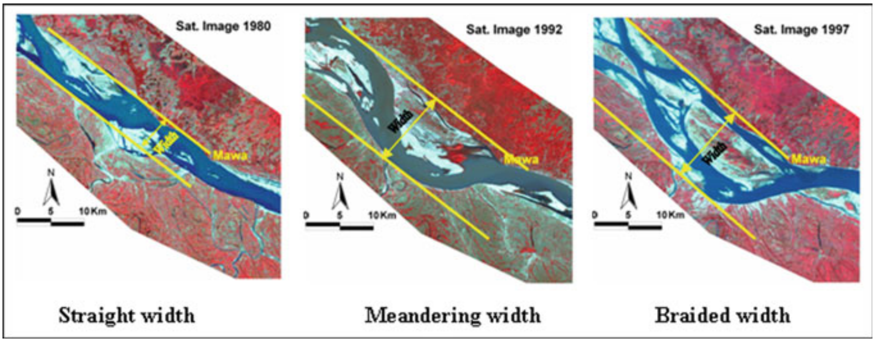


Fig. 7.22 Definition diagram showing the method of estimating straight, meandering, and braided widths. *Source* CEGIS (2009b)

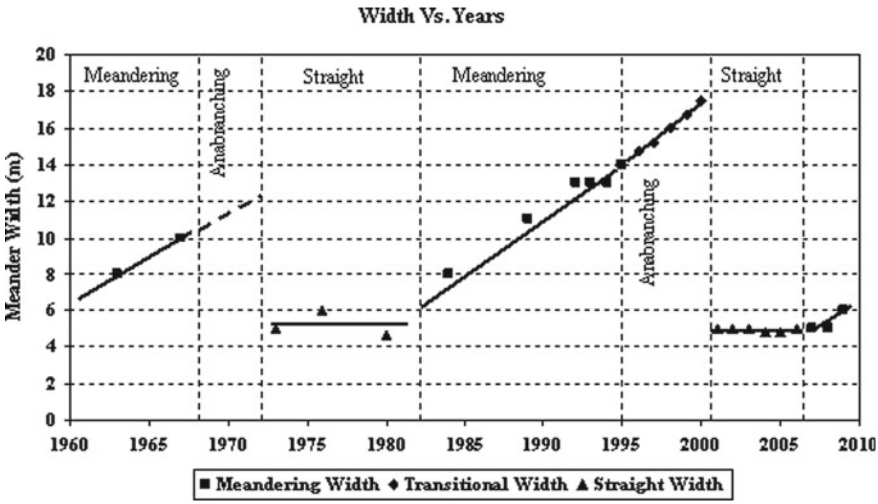


Fig. 7.23 Changes in straight, meandering, and branching width of the Mawa reach of the Padma River. *Source* CEGIS (2009b)

Dynamics of Coastal Islands

The Estuary Development Programme (2007–2011) of the BWDB with financial support provided by the Government of The Netherlands (GON) made extensive use of remote sensing to understand the morphological processes with a view to improving disaster management and the management of natural resources in the coastal area. EDP selected two pilot intervention sites for assessment of recent planform development, comparison with historical planform developments which facilitated assessment of future developments with a focus on locating potential sites for cross-dams. One of the sites is Bhola—Char Borhan-Char Montaz as shown in Fig. 7.24.

Since 1973, landmark changes in the planform of the southwest part of Bhola are seen in the form of emergence of Char Islam having an area of 20 km^2 and reduction of the distance between the chars through reduction in the width of the channels separating the chars. Most of the changes in this area occurred during an eleven-year period between 1984 and 1996. Analysis of the data generated from satellite images indicated that erosion and accretion during the 12 years from 1996 to 2008 were not very significant. Shoreline movement was nearly frozen in the south of the Bhola Island, Char Islam, Char Montaz, and Char Kukri Mukri. Based on the trend of the previous 12 years, the study concluded that there will not be major changes in this area in the immediate future. It also concluded that pilot interventions for accelerating accretion are not likely to bring a major benefit to this area other than connecting the chars to the Bhola Island.

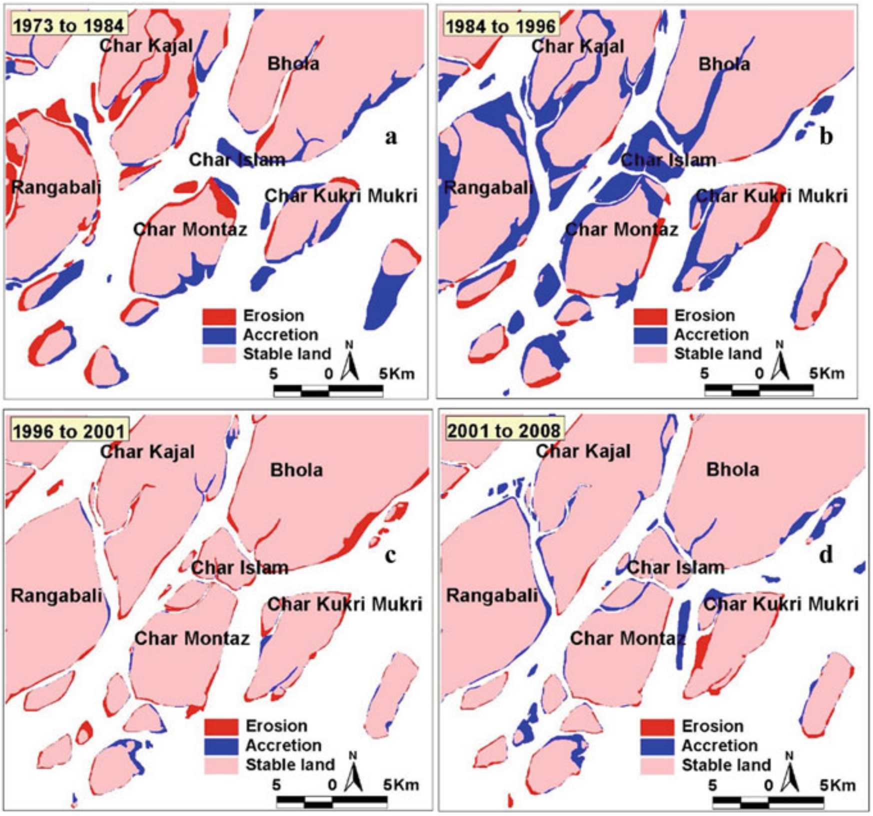


Fig. 7.24 Erosion and accretion in the southwest of Bhola over time. *Source* CEGIS (2009a)

Milestones in Research on River and Char Dynamics

During the last four decades, several studies and research on the behavior of physical processes of the rivers, estuaries and coasts of Bangladesh were carried out using mainly satellite images. Two of these milestone research/studies carried out by CEGIS are presented below.

Erosion Prediction

Dry season satellite images have been used intensively as a rich source of information and the basis for predicting bank erosion of the major rivers. FAP 21/22 developed predictive tools to select locations of sites in the Jamuna River for bank protection pilot studies (Klaassen et al. 1993) using time-series Landsat MSS images with 80 m

$\times$ 80 m resolution from 1973 to 1988. EGIS (2002) took an initiative to update the tools and further develop the tools using higher resolution time-series Landsat TM images from 1992 to 2000 with spatial resolution of 30 m $\times$ 30 m.

Relevant data such as bank and bankline, water width, curvature of the flanking channels, and proximity of other planform features such as confluence and bifurcations were extracted from dry season satellite images. Several hundreds of data were extracted from images and subsequent superimposition of the data on banklines provided information for monitoring the erosion and accretion and making predictions. Analysis of data was carried out in a probabilistic environment, and the results of prediction were presented in a stochastic manner.

CEGIS has been predicting riverbank erosion of the Jamuna, Ganges, and Padma rivers for the last 15 years. Every year, in February or March, a comprehensive erosion vulnerability assessment is conducted of the three rivers which is based on the latest dry season satellite image of that year. A report is prepared that identifies all erosion vulnerable areas on the banks and predicts bank erosion for the following year in terms of areas in hectares likely to be lost to erosion as well as potential loss of infrastructure. A sample prediction map is shown in Fig. 7.25.

The report is disseminated among national agencies such as BWDB, LGED, DMB, RHD, ,BIWTA and NGOs such as BRAC and CARE. Consultants and contractors of water management projects are the main users of the report. However, there is no regular source of funding to sustain this effort in the future. Also, directives to take advantage of the predictions for management and planning are absent from the government side. Similar predictions using time-series satellite images were carried out for the Kosi River in Bihar, India, by CEGIS from 2014 to 2016. The critical issue in the case of the Kosi River was to assess the vulnerability of the flood embankment and spur fields for protecting the riverbank.

Sediment Slug

Responses of the braided river system to the sediment slug generated by the Assam Earthquake of 1950 were studied by Sarker and Thorne (2006, 2009). Intensity of the earthquake in Richter scale was 8.6, and it caused huge landslides in the Himalayas amounting to 45 billion m^3 (Verghese 1999). A major part of the sediment poured into the Brahmaputra River and finer fractions of sediment (silt and clay) traveled through the Brahmaputra–Jamuna–Padma–Lower Meghna braided river system before reaching the Meghna Estuary without noticeable change in the river's morphology. Due to significantly low fall velocity, the river does not have to spend much energy for transporting the fine sediments. These fine sediments gain fall velocity due to flocculation while mixing with saline water in the Meghna Estuary. Thus, these sediments play an important role in shaping the estuary morphology.

To transport the coarser fraction of sediment (i.e., fine sand), the river has to spend energy, and there is a limit to how much sediment it can transport in a particular setting of the river regime. During the downstream propagation of the sediment slug, the river

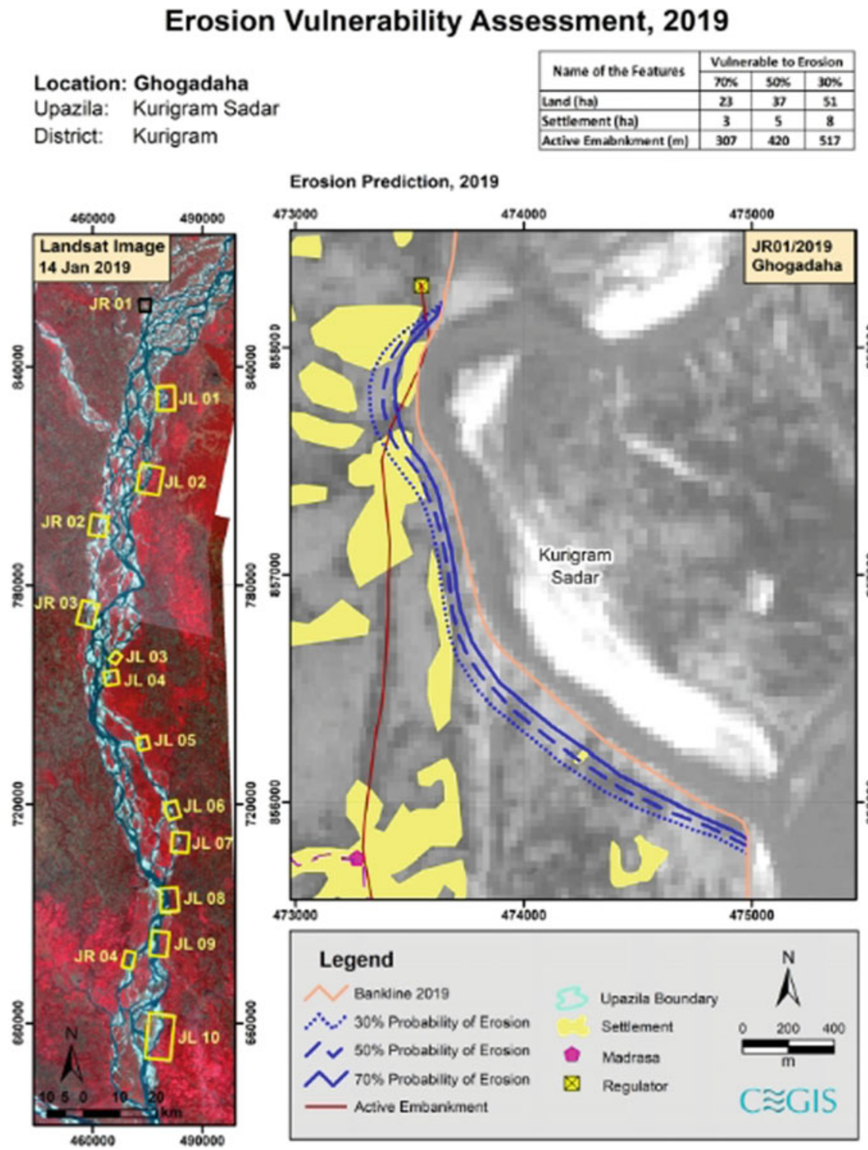


Fig. 7.25 Erosion prediction and vulnerability assessment of the Jamuna River. *Source* CEGIS (2019)

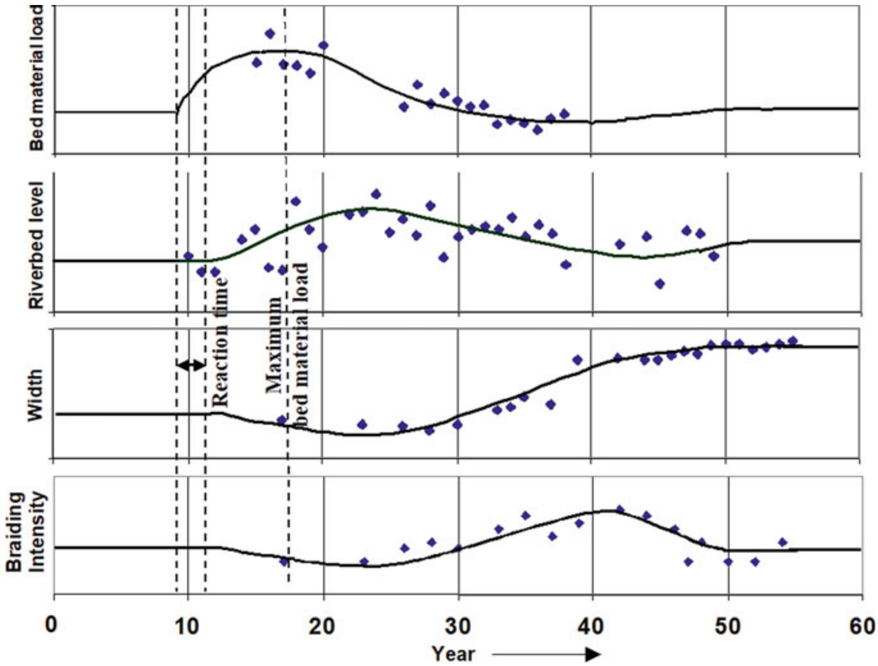


Fig. 7.26 Process-response model describing the response of the braided rivers to the changes in bed material load. Modified from Sarker and Thorne (2009) as observed from satellite images and other field data

regime changed by widening and narrowing, aggrading and degrading of riverbed, and changing of braiding intensity (Fig. 7.26). In this figure point, data represents data measured in the field (bed material load and bed level) or data extracted from satellite images (width and braiding intensity). Initially, the process-response model of Fig. 7.26 was derived for upstream reach of the Jamuna River and validated for the lower reach of the Jamuna, Padma and Lower Meghna rivers. This model has the potential to explain the past and present processes of the rivers and predict future developments under various scenarios.

Conclusions

Remote sensing has been employed in a plethora of applications in the field of riverine chars and coastal islands. It has proven to be an essential tool in river management, riverbank protection, coastal management, estuary development, and a wide range of research activities including rivers and chars. Analysis and understanding of the dynamic systems would not be possible without satellite data acquired at short intervals. Innovative work such as erosion prediction, and in-depth studies on response of systems to sediment slug also would not be possible to this extent without using remote sensing.

So far applications have mostly involved the major rivers and the estuary. Medium resolution satellite images with resolution ranging from of 20 to 30 m are found to be optimal for this purpose considering the size and scale of dynamics, revisit period of satellites, image availability and cost. To study smaller rivers and their chars where the scale of changes is much smaller, higher resolution images would be required. Image processing and data extraction steps highlight the importance of maintaining accuracy in processing and consistency in the interpretation of the images for accurate time-series analysis.

A considerably large satellite image database has been developed in Bangladesh most of which is hosted by CEGIS. The technical knowledge and expertise which has been developed to process the images and interpret them with the required accuracy for morphological studies is highly valuable. With the decades of experience, scientists and engineers have found innumerable ways to exploit the database to enhance and enrich the study of rivers and chars.

Recommendations

The scientific and technical knowledge that has been developed in the application of remote sensing for morphological studies is of national interest, and hence, it needs to be preserved and advanced. Most of this knowledge/technology is currently with a handful of research organizations including CEGIS, SPARRSO, and LGED. For further dissemination and development, it should be included in the education curricula and research in technical universities.

Morphological analyses and predictions have the potential to play an important role in water resources planning including char and coastal island development. So far, analyses and predictions have been carried out on an ad-hoc basis. It should be institutionalized to utilize its full potential at both national and community levels.

Remote sensing technology is continuously evolving. It is necessary to keep track of this evolving process by exploring various types and sources of satellite images for continuity, improved resolution and accuracy, as well cost-effectiveness of the application. Emerging technologies such as drone technology should be explored for enhancing the accuracy of analyses at the microscale. Given the extensive dataset of multispectral images, classified land use raster, and bankline vector data that are available for morphological analyses, machine learning, and deep learning models can be used for "learning" the knowledge that this large dataset contains, so that the knowledge can be leveraged for automated processing of new images. This has the potential to bring consistency in processing and interpretation for a more robust morphological analysis.

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Chapter 8
The Morphology of Riverine Chars

Knut Oberhagemann, Maminul Haque Sarker, and Iffat Huque

Abstract This chapter provides an overview of the char dynamics of the Jamuna and Padma rivers in Bangladesh, which are part of the Lower Brahmaputra River. Riverine chars are major morphological elements and together with number and size of channels determine the river characteristics, for example, with respect to navigability, flooding, and riverbank erosion. The char dynamics have created a very distinct culture with the lives of the potentially two million char people being much different from the life on the stable floodplains. During the last half-century, chars became very short-lived, particularly in the Brahmaputra/Jamuna, which impacted the lives of the char dwellers. On the positive side, the overall widening of the river corridor increased the char area significantly, however at the cost of floodplain land and the population there. The systematic study of char dynamics became possible with the development of satellite imagery from the end of the 1960s. Increasing resolution and regular annual imagery helped much to understand the interaction between chars and river channels and how their vertical buildup above low water levels influences land use and eventually settlement patterns.

Keywords Erosion · Riverine chars · Channel migration · Padma River · Brahmaputra-Jamuna River · Meghna River · Char dynamics · River stabilization

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Introduction

This chapter provides an overview of morphological processes of the main rivers of Bangladesh with special focus on the formation of islands and chars that char dwellers call their homes. The chapter indicates the importance of chars in the main rivers, how variable they are, and how large events like tectonics associated with the mountain building process of the Himalayas have played a major role in char formation and stability over the last half-century.

After an introduction to the morphology of chars and the estimated population living on chars but also affected by river widening, the chars in Jamuna and Padma rivers are more closely described. This is followed by a brief discussion looking at the characteristics of the other large rivers of Bangladesh, the Ganges and Upper Meghna. The paper concludes with potential future changes to the char environment not only from natural processes but also human interventions.

This chapter builds on a large number of studies conducted over the last 25 years. The initial work goes back to EGIS (1997), (2000), and Sarker et al. (2003).

Morphological Background

Chars are typically islands (however, some are attached) in the main rivers of Bangladesh, typically vegetated, often occupied and used by people. The main rivers are the big rivers that have formed the Bengal delta, the large Ganges and Brahmaputra rivers, being among the ten largest rivers in the world, and the much smaller Meghna River. Chars play a special role along the Brahmaputra River System (Fig. 8.1), starting from Pasighat in Arunachal Pradesh and discharging one of the highest water and sediment loads on earth into the Bay of Bengal, 1150 km downstream. Along the way the Brahmaputra in Assam (flowing from east to west) changes its name to Jamuna at the offtake of the Old Brahmaputra in Bangladesh and after combining with the Ganges, to Padma River (flowing from west to east). After turning sharply south at Chandpur, the river is known as Lower Meghna River, and forms one of the largest estuaries in the world.

Chars play a special role in this river, as the upper 900 km of the Brahmaputra System are morphologically characterized as braided. This means a multitude of channels braids around many islands and sandbars[1] of ever-changing sizes and locations. In morphological terms, these bars and islands, or chars are sediment transport features. Sediment transport features are an expression of the amount of sediment the river moves to the sea. It is the sand that constitutes the chars and defines the river planform. Often this sand is not seen as it is transported at the bottom of a river channel. This sediment is known as bed material.

[1] Sandbars are chars too except for that they go under water during normal flood seasons. The sandbars are used by local people during the winter or dry season.

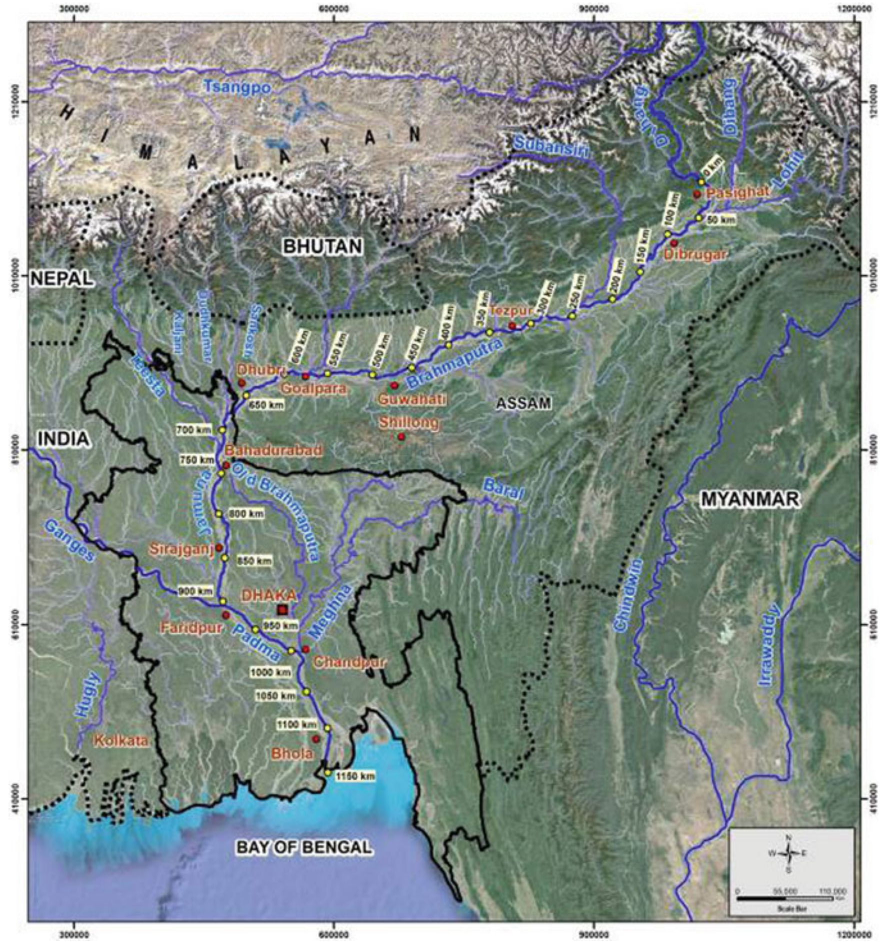

Fig. 8.1 The braided Brahmaputra System. *Source* Authors

Generally bed material transports as bed load, however during the monsoon most of the bed materials transport as suspended load which allows the bed materials to deposit on the surface of low lying sand bar and islands. Changes in the amount/size of bed material caused the metamorphosis of the river morphology. Finer fractions (silt + clay) of sediment transports in suspension mode, rarely deposits on the riverbed and this is known as wash load. It does not participate in the metamorphosis of river morphology. When the river reaches the estuary/coast, the wash load mixes with the brackish/saline water and flocks. Due to flocculation, wash load gains fall velocity, deposits at the estuary and actively participates in the morphology of the estuary and coast. The ratio of bed material and wash load varies over time within 20–35%. If we assume that on average one billion tons of sediment enter into the estuary annually, the amount of bed material would be only approximately 150 million cubic meters.

The Brahmaputra System exhibited dramatic changes in responding to the huge sediment input after the Great Assam earthquake dislodged some 45 billion cubic meters of sediment and overloaded the river system in 1950 in different phases. While the wash load moved quickly and deposited in the Meghna estuary within few years, the bed materials traveled slowly as sediment slug and took about 5 decades to reach the estuary. The peak of the sediment slug has reached the coast during the period 1990 to 2000—50 years, or two generations, after it started. So, our limited human experience today mostly remembers the dramatic widening of the river and the very unstable chars. However, this widening has come to an end with the decline of the sediment wave, and the river system today is overall more stable than two or three decades ago. This stability will last until another disrupting event (like an earthquake) will trigger the next major changes. Some estimates say that great earthquakes can occur every 50–100 years, while other estimates say these events happen only hundreds of years apart. From a social point of view, it is important to recognize that while the widening of the Brahmaputra has benefited the char area a lot, it has caused great losses of the more densely populated floodplain land.

Downstream after meeting the Ganges, the Brahmaputra System becomes more stable. The moderating effect of the much more predictable meandering Ganges River translates into the Padma, as the river is called here. Combined with the braided Brahmaputra of many channels, the resulting Padma flows with one or two channels around large, much more stable islands. Chars sometimes even combine with the floodplain, when one of the two surrounding channels declines completely. Then these chars are called attached chars. The Padma chars change over decades, in some cases it takes more than 25 years to run through a cycle of changes. In the more recent past this has led to great infrastructure developments on generally unstable chars. People have constructed five-story buildings and consequently, when the river returns after a long time to erode them, there is much pressure on the government to protect this valuable infrastructure.

Apart from distinguishing between the heights, the location also plays a role. Chars are higher land that is vegetated, while sand bars are lower land that is mostly flooded. Relevant to settlements is the higher land, and the location plays a role: either in the river or close to the bank. In the river these are islands. Close to the bank as attached chars, chars can become indistinguishable from the floodplain over time.

Changes in River Courses and Impacts

There is great uncertainty about the number of people affected by the river widening over the last half-century. The uncertainty is associated with the difficulty to establish reliable demographics of a dynamic, fast growing population. The issue is compound by the inaccessibility of the riverine chars and the fact that a population census is conducted only during the first year of each decade (Fig. 8.2). The analysis of the affected population is helped by the fact that satellite imagery is available since the

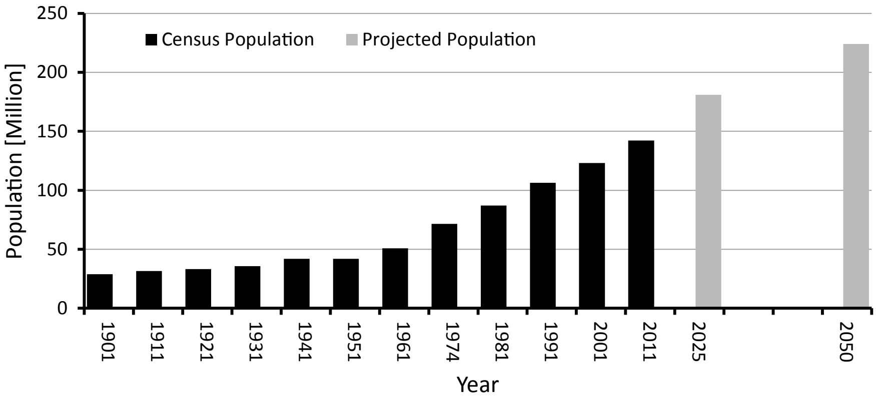

Fig. 8.2 Population development in Bangladesh. *Source* Bangladesh Bureau of statistics and national water management plan

independence of Bangladesh and there is a very good understanding of the floodplain land lost to the river and char area changes.

Rivers change in multiple ways resulting in diverse impacts on chars and floodplains. The widening of the rivers has led to an increase in the total char area, but at the cost of stability: There are more chars, but they change quickly. Along the riverbanks much floodplain has been eroded (Fig. 8.3), up to some 5000 ha per year, displacing many people permanently and driving a large number into poverty. Overall, Bangladesh lost some 180,000 ha of land along Jamuna and Padma over the last 50 years, with very small gains from accretion.

The census from 2011 provides more detailed union level population data as opposed to the coarser upazila level data. This allows approximating the population on chars better. This first step analysis is then combined with erosion and char area

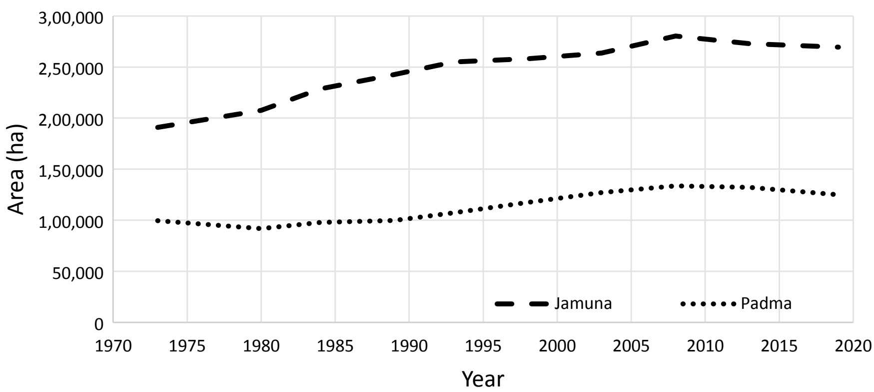

Fig. 8.3 River widening of Jamuna and Padma Rivers. *Source* Processed CEGIS bankline data

data and extrapolated to historic census data. Figure 8.4 shows the population development over time, while Fig. 8.5 demonstrates the differences when looking at the finer resolution union level data. While the population density increases substantially over the years, it is clearly visible that the upazila and union population density within the river corridor remains markedly lower than on the floodplain.

What is striking is that the population density on chars, even though looking much lower on the maps, is in reality close to the average population density of Bangladesh. The simple reason is that less than half of the area within the river boundaries consists of vegetated chars, fit for settlement. In 2011, the population on the left and right bank of the Jamuna was around 1250 and 1400 persons per square kilometer, as opposed to 420 in the river. When accounting for the fact that only 45% of the river land is char land, the population density on the chars increases to nearly 950 persons per km^2.

From the early 1970s until 2011 the population within the river corridor has more than doubled from an estimated 0.7 million to around 1.5 million. However, from 2001 until 2011 the population increase is small and we can expect that by 2020 still less than 2 million people live within the river corridor of Jamuna and Padma. The population density on chars has increased from around 500–930 persons per square kilometer. The lower increase in population density on chars than on the floodplain is explained by the widening of the river and the additional char land available. The changes in char area from year to year naturally result in abrupt changes of the population density. For example, there was only 30% vegetated char land available in 2001 as opposed to 45% in 1973 or 2011.

When looking at the widening process with the eyes of a floodplain dweller, the picture is one of tremendous loss. While the erosion rates have declined during the last two decades, the population density on the floodplain continues to increase. From 1973 until 2001 the aggregate erosion was 1265 km^2 displacing around 1.5 million people. From 2001 to 2020 the aggregate erosion loss has come down to 538 km^2 or 40% of the earlier one, however still 0.8 million people, or 53% or the earlier number have been displaced. Overall, 2.3 million people have lost their land, more than the total population on all chars.

The Jamuna Chars

Location and width of the Jamuna are variable and consequently affecting the location and areas of chars. Figure 8.6 shows the river corridors over the last two centuries. The boundary lines in 2010 are on average 12 km apart. Over the last half-century, the erosion rates increased from a little above 1000/ha per year during the 1970s to more than 2500 ha per year during the 1990s and have returned to a little over 1000 ha per year during the 2010s. This riverbank erosion adds additional sediment to the river corridor and contributes to the growth of chars. Reduced riverbank erosion means reduced char growth and consequently, the channel and island pattern is becoming more stable.

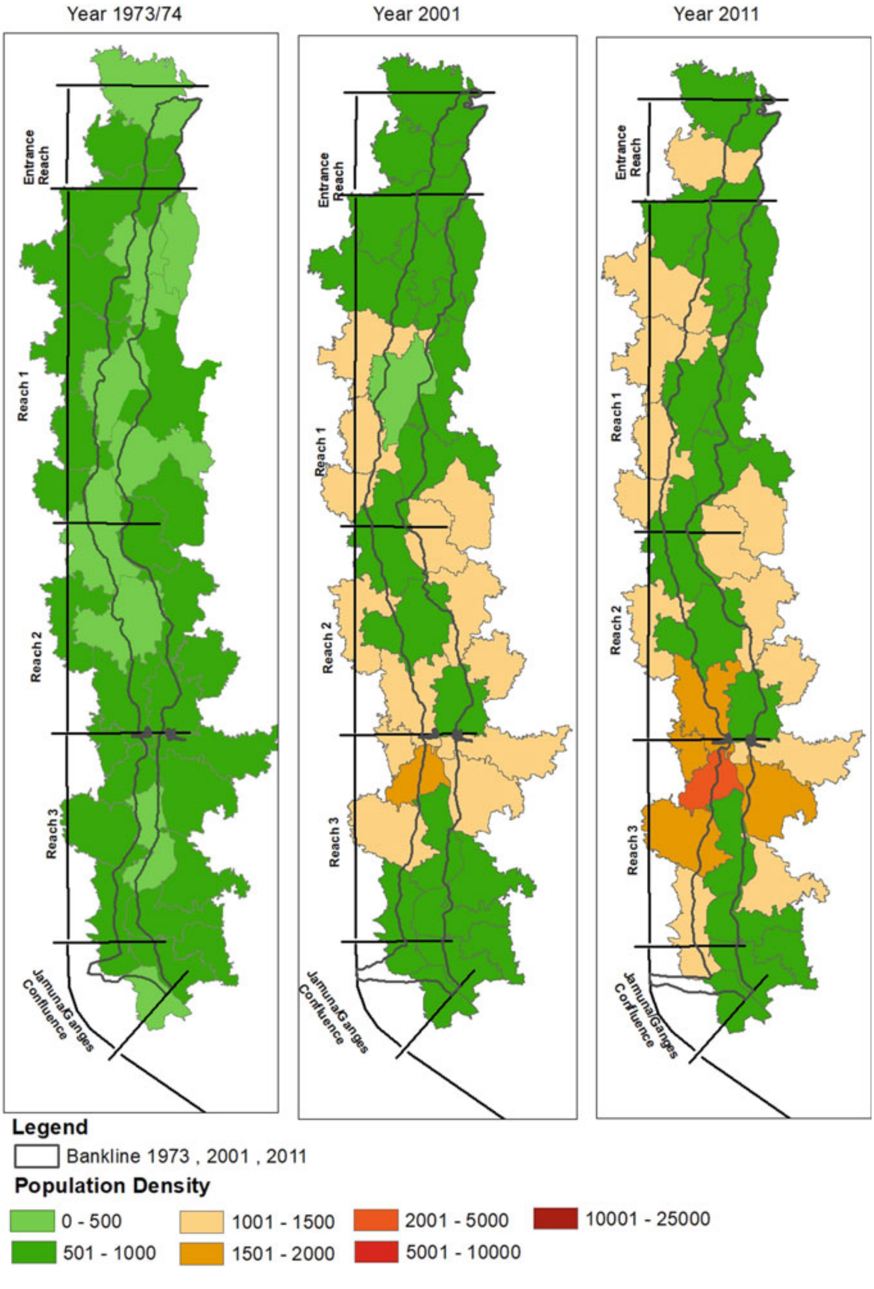

Fig. 8.4 Jamuna: Upazila wise population and bankline developments: 1973/4, 2001 and 2011. *Source* Authors based on BBS data

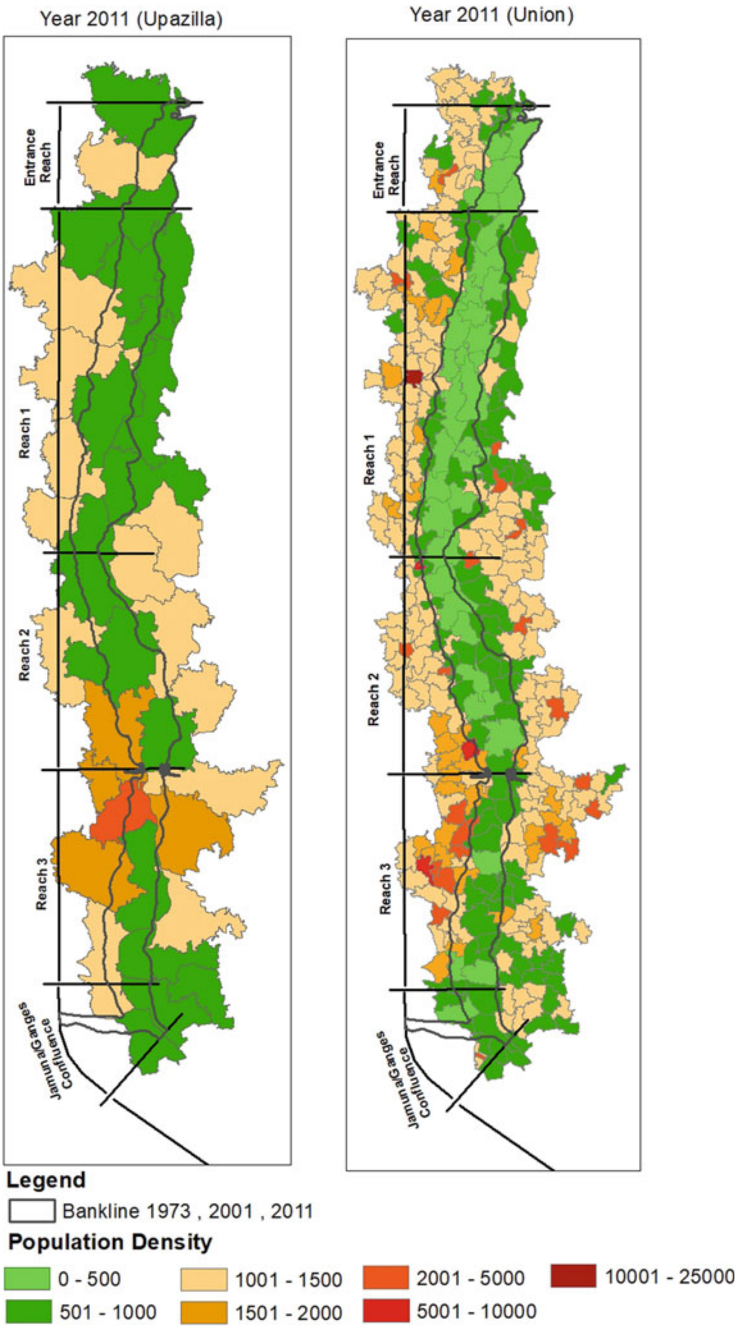

Fig. 8.5 Upazila and union population density along the Jamuna River. *Source* Authors based on BBS data 2011

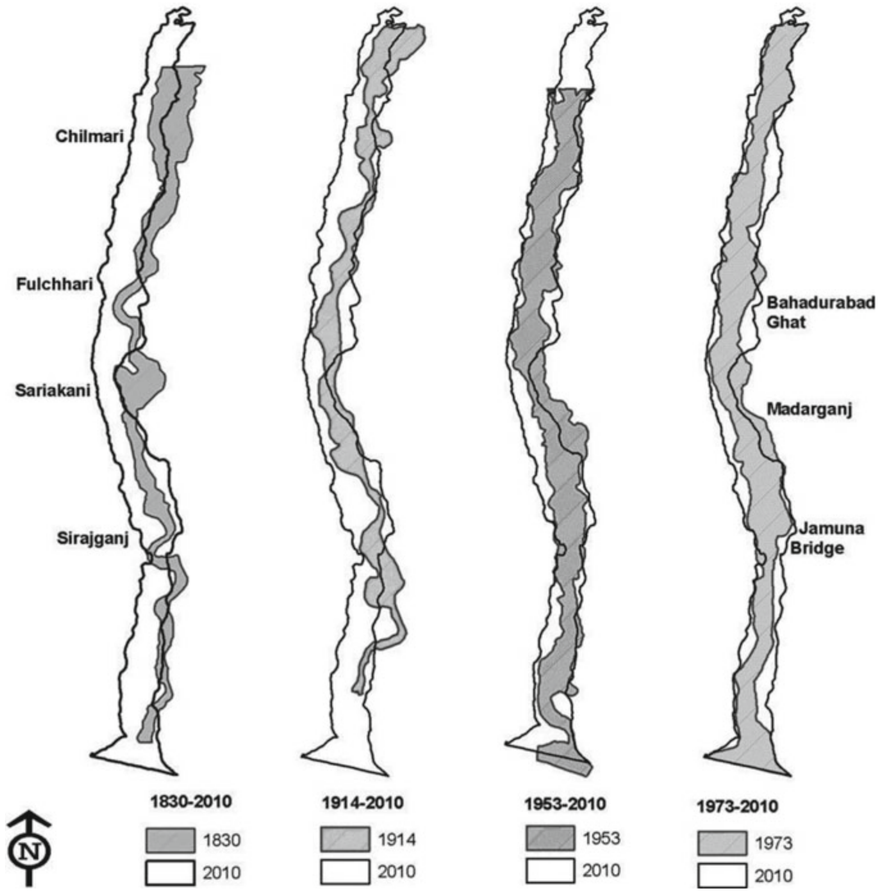

Fig. 8.6 Changes in the Jamuna river corridor over the last two centuries. *Source* CEGIS Dhaka

The char area reflects the changes of the river, particularly during the period of maximum widening in the 1990s. Figure 8.7 shows how the area has changed over time. The beginning of the graph corresponds to the time when reliable satellite imagery became available, in 1973. The graph excludes the upstream and downstream transitional reaches of the Jamuna and therefore does not correspond to the total river area. It is quite evident how the river corridor increased steadily until the early 2000s. This resulted in a steady increase in sand and land, or bars and chars. Bars are not vegetated as they remain flooded for extended periods of time and only show on the dry season satellite imagery, which is taken at the lowest water levels. Chars are vegetated and used agriculturally, and only flood every few years during higher floods**.** In the 1990s there was much growth of bars, or sandy area, associated with the rapid widening at this time. Over time, these bars consolidated, grew in height

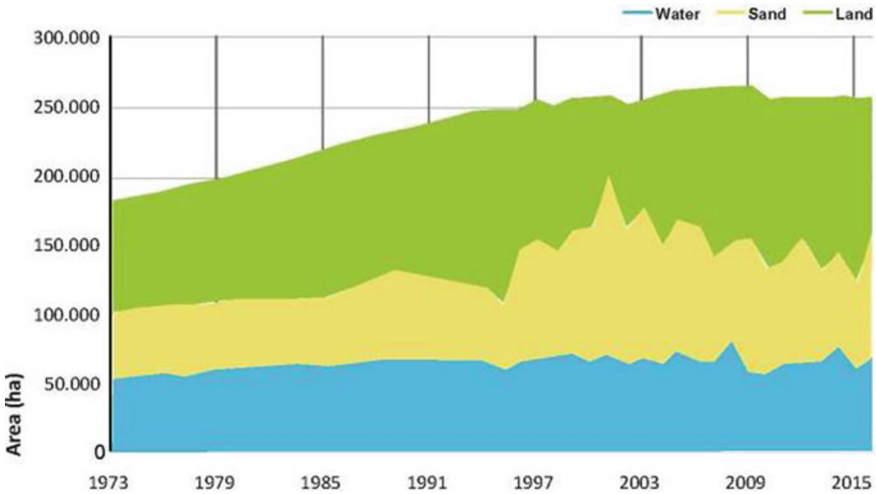

Fig. 8.7 Area of water (blue), sand (yellow) and land (green) along the main part of the Jamuna River. *Source* NHC and EMM (2020)

and became vegetated. While in 2000 chars were around half of the bar area, the ratio is the opposite now. Another indication that the river has become more stable.

The Jamuna River does not exhibit a uniform behavior along its length. There are large differences between the 90 km long upstream, and 60 km long central and downstream reaches. When we look at the char age over a period of around two decades (from 1994 until 2015), we notice that the chars in the upstream reach are much less stable than those in the central and downstream reaches. Figure 8.8 shows that most chars in the upper reach are less than ten years old, while most of the chars in the central (as well as the lower reach) are more than ten years old. Despite being more stable, the chars in the central and downstream reaches are still very mobile. This explains why people living on these chars report of frequent shifting of their houses. The example of the chars at Kazipur explains this in more detail (Fig. 8.9). The group of chars in this area perpetually changes locations as channels cut across then widen or get abandoned.

Naturally, the char dynamics have large implications on human settlements and the land use. The latter much depends on the age of the char, as older chars are more fertile. Over time, successive flood seasons deposit more and more fine silts and build a fertile top layer. Being largely a result of the high sediment load, and specifically the bed forming sand load, the chars are normally sandy (Fig. 8.10).

Contrasting the infertile sand, fertile floodplains consist mostly of fine silts and clays. This fertile layer of finer material only forms over time, when the suspended sediment is carried in the flowing water body deposits during higher floods (see Chap. 10). The deposition is favored by vegetation that slows the flowing water down and results in higher deposition rates (Fig. 8.11).

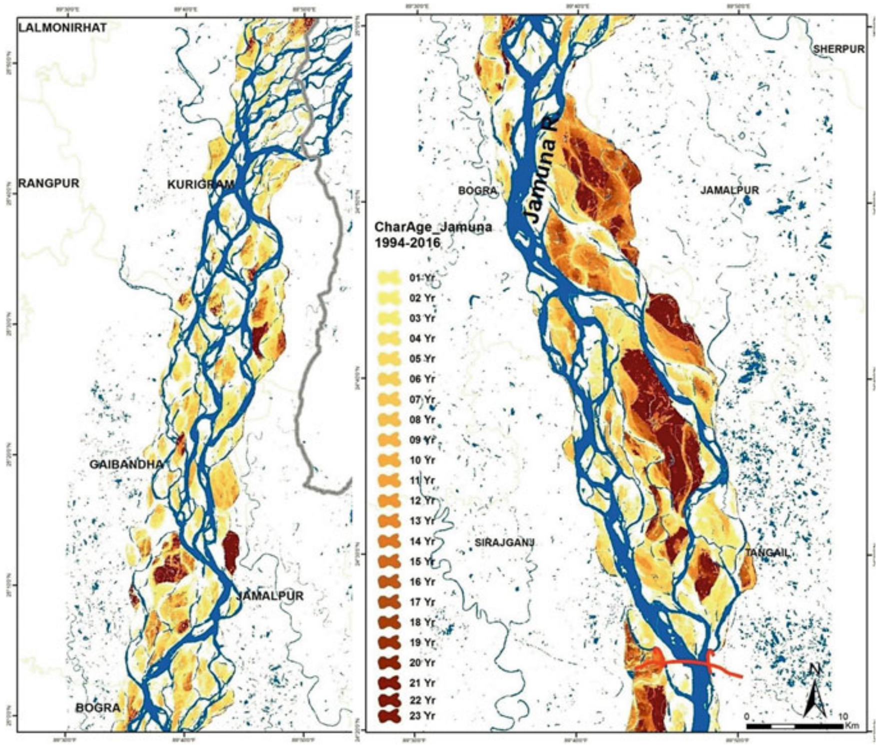

Fig. 8.8 Char age for upper reach (left) and central reach (right). *Source* NHC and EMM 202

Limited experiments with reed plantations at Bhuapur, upstream of the Jamuna bridge crossing during the 1990s, resulted in more than two meters of sedimentation in one flood season. Overall, the lack of consistent long-term survey data does not allow a clear assessment of the vertical buildup and char use over time.

Two investigations in 1997 and 2013 show quite different results (Fig. 8.12). While the first study indicates it takes about five years to reach the floodplain level, corresponding to 5.5 m above public works datum, the later study shows it might take up to 12 years. The difference could also be associated with a reducing sediment load after the sediment wave has passed. Thus further study is required on this subject.

Finally, it is to be noted that chars can also disappear completely. The Old Brahmaputra course, which the river took before it entered into the Jamuna at the beginning of the nineteenth century, is completely silted up today with only a small channel remaining (Fig. 8.13). Therefore, disappearance of the chars here is not due to the common erosion factor, but due to the river itself drying up significantly.

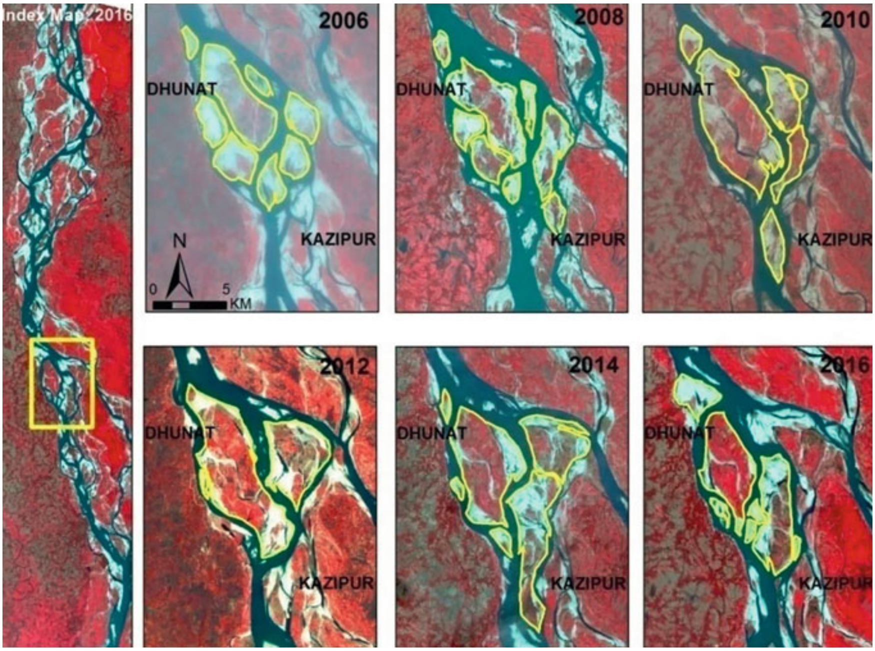

Fig. 8.9 Char dynamics in the central Jamuna over a period of one decade. *Source* NHC and EMM 202

Fig. 8.10 Sandy char soil with vegetative cover. *Source* Lead author

Fig. 8.11 Reeds (catkin) slow down flow velocities and encourage the deposition of fertile finer particles during the flood season. *Source* Lead author

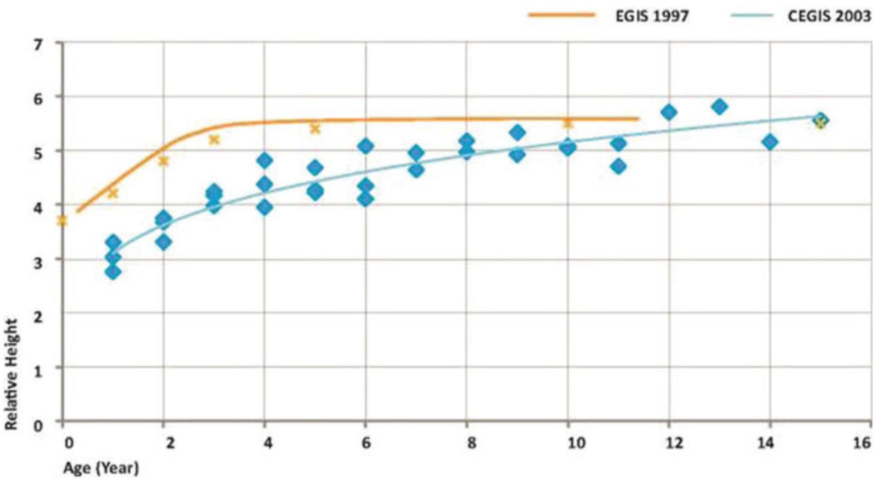

Fig. 8.12 Vertical char growth. *Source* EGIS (1997) and CEGIS (2013)

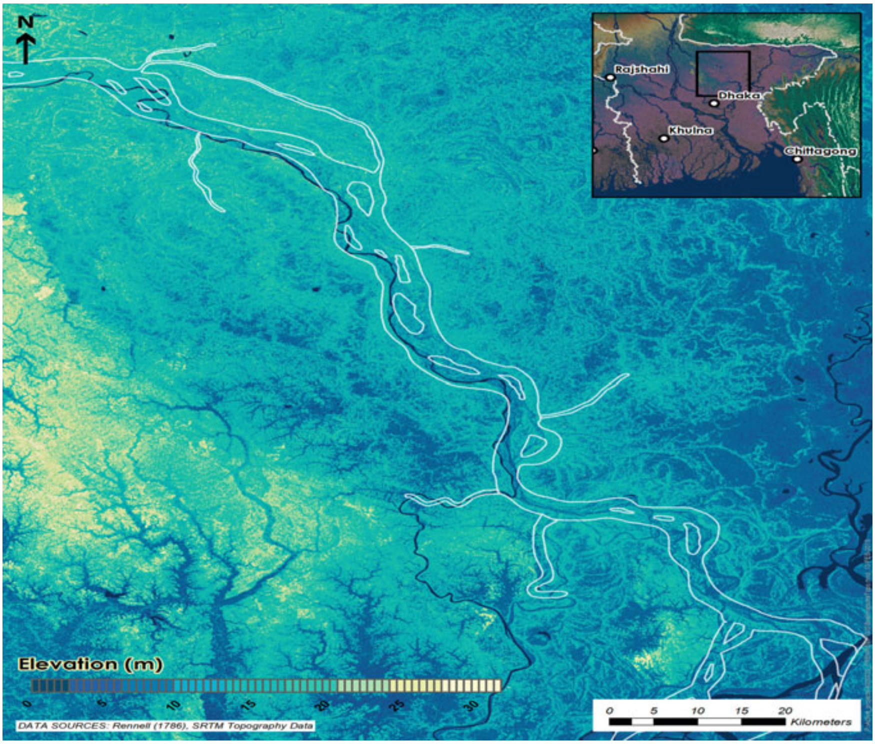

Fig. 8.13 Superimposition of the Old Brahmaputra course in 1765 and its modern-day channel

The chars, clearly visible on the map published in 1780, surveyed by Capt. James Rennell between 1764 and 1777, all have become floodplains. The population living along this branch of the river has greatly benefitted from large land gain, even though the land might be less fertile than the surrounding much older floodplain in this region of northern Bangladesh.

The Padma Chars

Similar to the Jamuna River, the Padma River has undergone large changes. It has widened and converted much floodplain land into charland. The widening process lasted about one decade more than the one for the Jamuna. This is the time the sediment wave took to arrive at the Padma. Also here the newly formed bars (expressed as sand in Fig. 8.14) were larger in size than the vegetated chars (during the 1980s). However, since some 20 years the vegetated land is clearly dominant and around four times larger than the sand. An indication for a more stable river over the last decades.

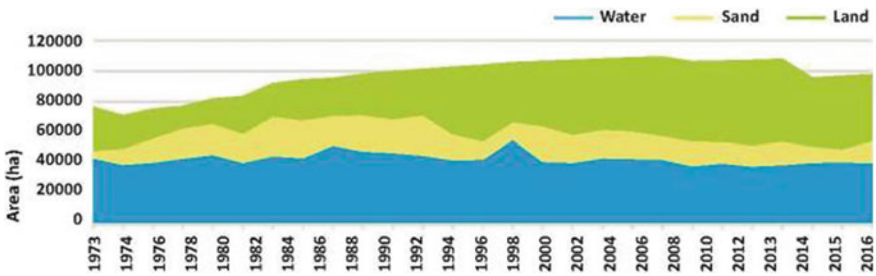

Fig. 8.14 Area of water (blue), sand (yellow) and land (green) along the main part of the Padma River. *Source* NHC and EMM (2020)

Concurrently, the char age is much higher than in the Jamuna and typically more than ten years old (Fig. 8.15). More downstream, at the confluence with the upper Meghna, the char age appears to be even older. It is interesting to note that the char in the Upper Meghna, close to Comilla is very old. Here the chars have the same characteristics as the floodplain land (Fig. 8.16).

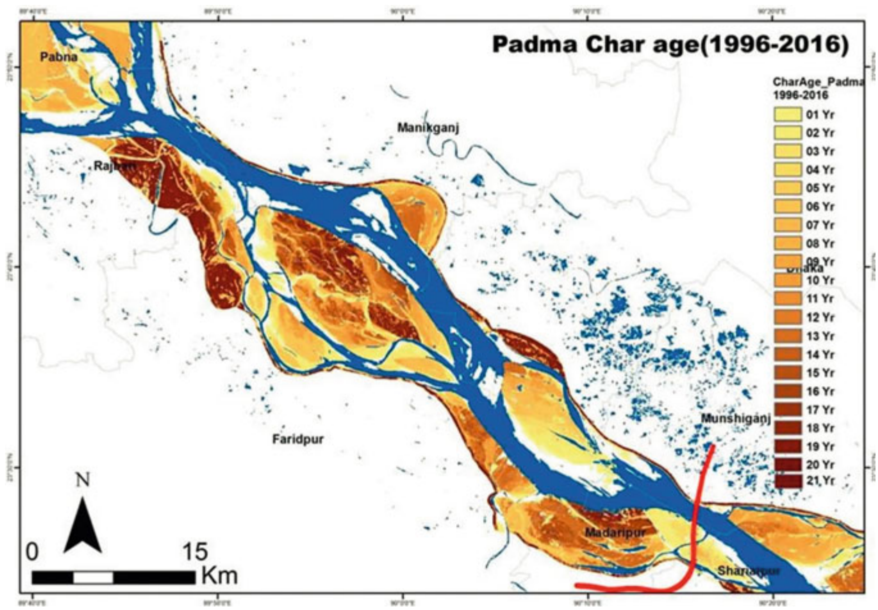

Fig. 8.15 Char age in the Padma River. The red line indicates the alignment of the Padma Bridge. *Source* NHC and EMM (2020)

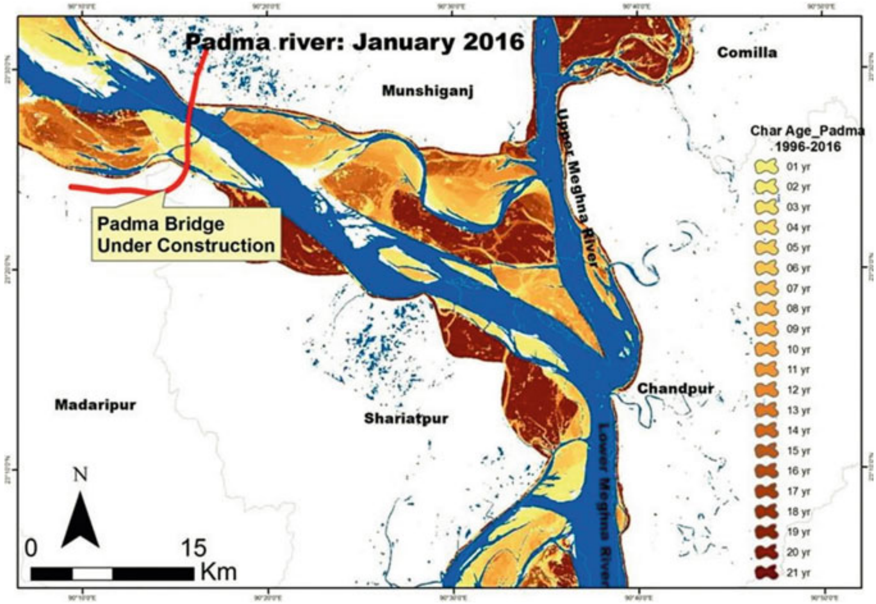

Fig. 8.16 Char age at the confluence with Upper Meghna. *Source* NHC and EMM (2020)

Other Main Rivers

Ganges

The Ganges is a meandering river, which does not develop dedicated islands or chars. The meander bends rather shift in location over time, leading to riverbank erosion at the outer bend and accretion of the inner bend. This accretion follows a similar pattern of sedimentation and settlement as chars, however happens in a much more predictable manner and does not classify as charland in a similar sense as in the Jamuna and Padma rivers.

Upper Meghna

The Upper Meghna is a stable river. While it formerly transported the flow of the Brahmaputra, following the course of the Old Brahmaputra until around 1800, it has become an “underfit” stream, which means it is too large for the discharges it carries today (Fig. 8.17). The relatively rapid expansion of the Jamun and corresponding decline of the Old Brahmaputra, has deprived the Upper Meghna of much of its sediment load. As a consequence a stable channel pattern has formed that exhibits very little erosion and deposition tendency. The Upper Meghna is tidal during the dry season months.

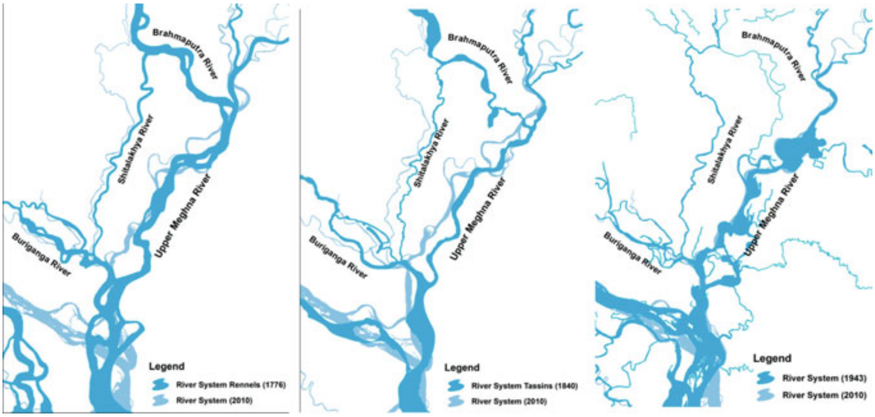

Fig. 8.17 Historical development of the Upper Meghna Course. *Source* NHC and EMM (2020)

Char Stability in Future

There are three main potential future changes that might impact the char stability: (i) river use for sand mining; (ii) upstream basin changes; and (iii) river stabilization with defined corridor and more stable chars.

From a morphological point of view all changes in water and sediment composition of the river are relevant, as they change the overall river characteristics. This could even mean that the braided river, with many chars in a multi-channel network, can turn into a meandering river with no chars at all. Actually, there are indications from historic maps that parts of the Brahmaputra and Jamuna were meandering in the past. All potential future changes impact the river in a way that potentially reduces the number and area of chars.

Sand Mining

Sand mining is a localized activity in Bangladesh with impacts depending on the sediment load and extraction rate. Some of the smaller tributaries from the Meghalaya mountains have experienced massive degradation due to the over-extraction of gravel and coarse sand for the fast growing construction industries (Bendixen et al. 2019). Sand mining does not stop at the Jamun and Padma rivers (Fig. 8.18). However, the extracted quantities are limited to the dry season and small compared to the annual sediment load, so do not have much impact on the river such as the Padma.

The impact would be different, if massive capital dredging were considered. A more recent concept paper (BWDB-BUET 2019) proposes to dredge around one billion cubic meters of sand in the Jamuna River. This corresponds to some 50 years of total annual sand load and would massively impact the river system up to the coast. In addition, the concept paper proposed to use up to two times the amount of dredged material for filling reclaimed char land to 20-year flood level.

Fig. 8.18 Local dredging of sand in Padma for construction industry. *Source* Lead Author

Upstream Basin Changes

There are great uncertainties about upstream developments, which are both natural and man-made. The annual variability of the monsoon with varying water and sediment discharges influences the river in unpredictable ways. In addition, large but infrequent earthquakes contribute to sediment overloading. It is, for example, possible that a future major earthquake happens in the area of Bhutan, closer to Bangladesh and with a faster and more immediate impact on river stability.

Man-made changes pertain to the extraction of water ('river interlinking') in India and to some extent in China. Another factor would be the storage of some of the monsoon flows in large reservoirs, particularly on the south flank of the Himalayas. Also land use changes, like increased logging could contribute to changes in sediment and water flows. Finally, climate change with expected increases in discharges until the middle of this century and subsequent gradual decline of the total water volume will play a role.

All these changes have long-term effects, are not predictable in their consequences, and in combination can result in a much less or more stable river planform (CEGIS 2010). As a consequence, Bangladesh as downstream riparian country can only respond and attempt to manage the future. The Bangladesh Delta Plan 2100 (GED 2018) provides the framework for this under "Adaptive Delta Management", a flexible approach leaving alternative pathways open and avoiding lock-in situations. There are some suggestions that river stabilization could help Bangladesh in the future. To this end, a number of river stabilization plans have been formulated that are briefly explained below.

River Stabilization

The Bangladesh Water Development Board has put high emphasis on stabilizing the main rivers. To this end four river stabilization plans or concept papers were published within two years (YRECC 2019, BWDB-BUET 2019, IWM 2019, NHC and EMM 2020). The plans/concept papers propose different concepts from narrowing the river and transferring it (at least in parts) into a single or double channel planform, to protecting the existing bankline against future erosion combined with the dredging in some cases of a double channel geometry.

The Bangladesh Delta Plan (GED 2018) includes a “reference scenario” from NHC and EMM (2020). The related river stabilization plan focuses on the Lower Jamuna and Upper Padma with major interventions planned over two Five-year Plan periods. The river upstream of the Jamuna bridge crossing is specifically excluded due to the large uncertainties pertaining to the future optimal planform. If the whole river corridor were converted mostly into a single channel meandering river, there would be the potential to convert all island chars into attached floodplain with some 50,000 ha of land recovered. However, this is a reference scenario for planning and outlining the upper maximum of what could be achieved through an engineering focused approach. It is more likely that in line with the Delta Plan alternative, more adaptive pathways will be followed in future, recovering only parts of the floodplain land lost over the last five decades.

In mid-2020, BWDB has taken the first step to a more stabilized Lower Jamuna by initiating a more holistic project approach. Planned activities range from stabilizing parts of the river course in a double channel, meandering pattern, providing a first stable offtake for the Dhaleswari System to re-introduce dry season flow to the areas around Dhaka, recover a limited amount of eroded floodplain land, in parts existing as attached char but also lower lying sand bars to be built up to floodplain level, and provide a flood embankment on the left bank to protect the Manikganj district against flooding. Stabilization, particularly of the main rivers has the potential to become a major focus, also given that the BWDB has created the specialist Office of the Chief Engineer River Management.

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Chapter 9
Formation and Dynamics of Coastal Chars in Bangladesh

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Abstract The tide dominated Meghna estuary is characterized by a sequence of distributary channels and islands/chars. While there are a few studies on morphological processes of the Meghna estuary in general, studies on the physical processes of the islands/chars in the estuary are sparse. Close to two million people live on some of these fragile islands and chars. Given the lack of scientific literature on the formation and dynamic processes of the islands/chars, the chapter analyzes time-series historical maps and satellite images in an attempt to fill the knowledge gap. The study reconstructed the history of the Meghna estuary and islands and chars using maps and satellite images, recorded various noticeable events in the estuary and islands, and identified related drivers. Thereafter, the processes of formation of islands/chars and the time required for this in different physical environments were verified. The dynamics of the islands/char formation include the processes of erosion/accretion, increase/decrease in size, changes in shape, and migration of islands/chars.

Keywords Meghna estuary · Island/Chars · Delta tide · Time-series historical maps · Satellite images

Introduction

The Meghna estuary is currently the active delta building estuary of the Ganges–Brahmaputra delta. The rivers Ganges and Brahmautra drain much of the northern and southern slopes of the Himalayas, which is a highly sediment yielding mountain range. The high volumes of sediment have produced a large and dynamic delta,

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extending over an area of around 100,000 km^2 (Goodbred et al. 2003; Hori and Saito 2007). In a tide dominated delta, islands/chars are the essential components. In Bangladesh, several million people are estimated to live on these islands exposed to natural and/or manmade hazards and disasters such as erosion, flood, drainage congestion, cyclone, and storm surge. In recent years, climate changes seem to have worsened the situation.

Figure 9.1 provides a map of the Meghna estuary. The names and sizes of various chars or islands are in Table 9.1. The life span and geographical location of such chars/islands are changing between decadal and centennial time-scales.

The changes of landforms in the estuary are much higher than that of islands/chars along the coast (Brammer 2014). Not only the islands and chars are unstable, also

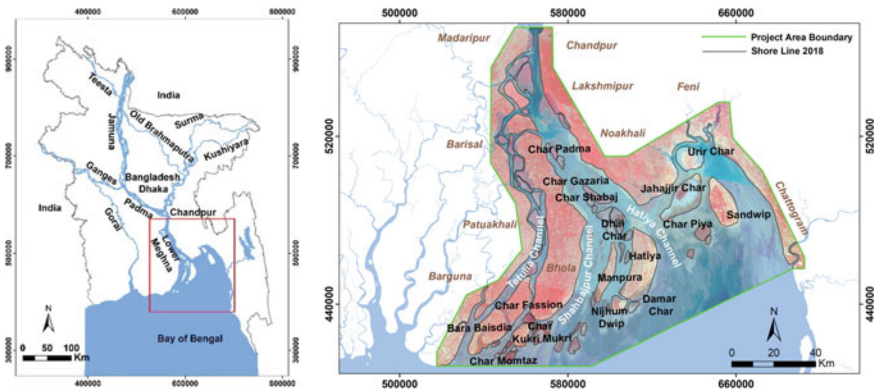

Fig. 9.1 Meghna estuary area in Bangladesh as per IRS LISS satellite image of 2018. *Source* CEGIS

Table 9.1 Char name and area (km^2) in the Meghna estuary area

Char name	Area (km^2)	Char name	Area (km^2)
Urir Char	107.00	Char Kukri Mukri	51.00
Jahajjir Char	227.00	Bara Baisdia	231.00
Sandwip	194.00	Char Gajaria	48.00
Hatiya	330.00	Char Shabaz	14.00
Nijhum Dwip	43.00	Dhal Char	127.50
Damar Char	19.00	Char Padma	40.00
Manpura	110.00	Bhola	1340.00
Char Montaz	94.00		

the boundaries and shorelines of the main land can migrate several kilometers per decade. Tide dominated deltas are very complex, and knowledge and predictability are limited. A few studies were done on the Meghna estuary. Unfortunately, no detailed study dedicated to the chars/islands was available.

People living in the island/chars are exposed to the sea, and they can become victims of cyclones and storms. A better understanding of islands/chars in the Meghna estuary, based on sound knowledge of physical processes active in the region, the effects of extreme natural events, and large-scale anthropogenic interventions could be helpful in combating climate change and sea level rise. Up-to-date knowledge and identifications of drivers of related issues can help in the effective and efficient management of the coastal islands/chars. Vegetated islands in the Jamuna, Padma, and Meghna Rivers are also known as chars. However, chars in the floodplains are relatively unstable, the average lifespan of which are about four to five years in parts of the Jamuna River. Islands in the Meghna estuary are more stable than riverine chars in Bangladesh (see Chap. 8).

In the Meghna estuary, there are several islands, the names of which are tagged with "Char," for example, Urir Char and Bhashan Char. Out of 15 islands, listed in Table 9.1, the names of 8 islands are tagged with "Char.". The age of those chars is typically less than 100 years, even though there are few large islands such as Bhola, Hatiya, Sandwip, and Manpura that are more than 240 years old. The fluvial process alone dominates the morphology of the riverine chars, while the interaction between fluvial and marine processes dominate the morphological process of the islands in the estuary. In popular parlance, there are differences between islands such as Sandwip/Hatiya and Urir Char or Char Kukri Mukri. In this chapter, we define all landmasses surrounded by the sea or tidal and non-tidal channels within the Meghna estuary and along the coast as "coastal chars." In other words, coastal chars include "islands." Riverine chars will be referred to as chars as described in Chap. 8.

Like the riverine chars, coastal chars are unstable, but to a different extent. Char dwellers both in the rivers and estuary have to face several kinds of natural and manmade hazards and disasters. Monsoon flooding and bank eorion are common hazards for the riverine char dweller. However, the extreme floods of 1988, 1998, and 2004 were disastrous, with casualties of thousands of people. On the other hand, erosion is one of the natural disasters, which is common for both chars in rivers, in the estuary, and at the coast. Cylones and storm surges are the biggest disasters for the coastal chars. The storm surge in November 1970 sadly took 300,000 lives.

Objectives

The main objective for assessing the stability of the coastal chars in the Meghna estuary is to know the life cycle of the island chars, which includes the process of development from a mudflat or sandbar to an coastal chars covered by mangrove forest or human settlement, its mobility, and chance of disappearance. Different types of largely unpredictable hazards/disasters, such as erosion/accretion, together with migration, influence the changing size and shape of islands. Furthermore, periodic cyclones and storm surges play a fundamental role in the life cycle of the coastal chars. Assessing the effects of those hazard is required to enhance the predictability of the physical system of islands. As the morphological dynamics of the islands are an integral parts of the morphology of the estuary, it is important to establish the relationship between physical process of the coastal/island chars and the estuary as a whole.

Recent Studies

Four earlier initiatives, dating back to the 1970s, namely the land reclamation project (LRP) (MES I 1999), Meghna estuary study (MES) I (MES I (1998), MES II (MES II 2001), and estuary development project (EDP) projects defined the Meghna estuary area for their study purposes. The area covered by the EDP of the BWDB is the area of the Meghna estuary, the northern limit of which is Chandpur and with the southern boundary-stretching more than 200 km from east to west (Fig. 9.1). Every year, the Ganges, the Brahmaputra, and the Meghna discharge about one trillion cubic meters (1000 km^3) of water and up to 1 billion tons of sediment into the Lower Meghna River. The flow carried by the Lower Meghna River is distributed by several channels to the estuary. According to MES II, the Tetualia channel used to carry about 15% of the monsoon flow, and the Hatiya Channel about 10%, and the rest is carried by the Shahbajpur channel (MES II 2001).

Tides are semidiurnal in the Bay of Bengal. The tidal range varies from 0.6 to 1.4 times the average range during neap and spring tides, respectively (Sokolewicz and Louters 2007). Based on tidal amplitude, Hayes (1979) divided estuaries into three categories based on tidal range, i.e., micro-tidal (0–2 m), meso-tidal (2–4 m) and macro-tidal (>4 m). All three of these characteristics are present in the Meghna estuary. The micro-tidal range is present in the Tetulia channel and the Lower Mehgna close to Chandpur, and the meso-tidal range is observed at the south of Bhola Island and north of Hatiya Island (Fig. 9.1). In the east of the Hatiya and Sandwip channels, the tidal range falls in the macro-tidal category. The maximum tidal range (>) 8.6 m was observed in the north-east side of Urir Char. MES I (1998) divided the main trunk of the Lower Meghna and Shahbazpur channel into three reaches: the river dominated reach, which ends 10 km upstream of the northern tip of Bhola, the mixed reach (both river and marine dominated) extends to southern end of Bhola, and finally the downstream, marine dominated reach.

The landform of the coast and estuary is believed to be determined mainly by the coastal and estuarine river flow, tidal ranges, and wave action (Douglas and Slingerland 2009). Later roles of sea level rise and climate change, anthropogenic interventions, influencing, for example, types and amount of sediment entering into the system, were recognized as secondary importance in determining the planform of the estuary and coast. Goodbred et al. (2003) related the frequent changes of sediment to seismic activities in the Himalayas, which far downstream modify the morphology of the estuary and the coast. Sarker and Thorne (2006 and 2009) and Sarker et al. (2011) presented the responses of the Jamuna, Padma rivers, and Meghna estuary to sediment (fine sand) slugs and entering of sediment fluxes of fine (silt and clay) sediment, which were derived from the enormous landslides in the Himalayas triggered by the 1950 Great Assam Earthquake (Verghese 1999). Fine sediment (silt and and clay) was transported down the Brahmaputra from Assam, India, to the Meghna estuary within a few years to a decade. The coarser sediment (fine sand) took more than 50 years to travel the same distance. Effects of phase lagging of the sediment slug became visible also in the estuaries and the understanding helped increasing the predictability of the delta building processes.

Approach and Methodology of the Study

While a number of studies addressed the physical processes of the Meghna estuary as a whole, till now knowledge on the complex physical process of the estuary is limited. Literature on the physical processes of coastal islands is sparse. Therefore, we studied the morpho-dynamics of the islands in more detail. Spatial and temporal data, such as historical maps and time-series satellite images, were used to reconstruct the history of the Meghna Estuary and its islands. Data on the estuary and islands were divided into different time-scales, such as millennial, centennial and decadal scales. Different types of events occurred in the estuary due to different outside (exogenous) and/or inside (endogenous) factors. In addition, anthropogenic changes occurred at different times.

The analyzed historical data show when changes occurred in the estuary, but does not provide the answer why they occurred. Sarker et al. (2011) described the decadal scale changes based on topo map (1943), time-series satellite images from 1973 to 2018, with spatial resolutions ranging from 80×80 m (Landsat MSS), 30×30 m (Landsat TM) and 24×24 m (IRS LISS) and temporal variations of 10–12 years. The time interval between the topo map of 1943 and satellite images since 1973 was 30 years with no other maps in between. The topo map of 1943 is not uniform as it was based on surveys from the period 1914 to 1939 and corrected landforms using aerial photos of 1943. In addition to the 1943 map, the older maps of Rennels (1776) and Tassin (1840) were used to reconstruct the history of the estuary over 242 years from 1776 to 2018.

Changes were analyzed for each pair of successive maps or satellite images and include widening, declining, and abandoning of distributary channels along with erosion and accretion, shape and size of chars, and islands. Changes within the estuary may be triggered by an event, which might be several hundred/thousand km away but within the basin of the contributory rivers (Brahmaputra and Ganges). The identifications of drivers (or the cause of changes) are not very straight forward process; because effects of the drivers may not be instantaneous, rather could have several years/decades phase lag. Moreover, effects of the drivers could be direct or indirect, which adds another layer of complexity when analyzing periods of noticeable changes in the estuary. At any moment, it is likely that effects of several drivers are going to occur simultaneously. In this case, centennial scale drivers were listed based on available literature and historical records, acknowledging that the analysis requires a good amount of expert gauging. The decadal scale analysis including process-response relationship in centennial time-scales was based on Sarker et al. (2011).

In the estuary, the process of land formation is visible when a bar (composed of fine sand, silt and clay) emerges during low tide. Time-series satellite images show the land formation process in different parts of the estuary. The centennial and decade scales are described for the islands of Bhola, Hatiya, and Monpura Sandwip considering their old age. For this article, additional investigations were carried out, for example, determining the influence of the tide on shaping islands, or identifying the drivers for centennial processes.

Setting the Scene

Most of the one trillion cubic meters of water, and one billion tons of sediment per year are delivered into the Bay of Bengal through the Lower Meghna River, originating from the combined flow of the Jamuna, Ganges, and Meghna rivers (Fig. 9.1). The annual average flood discharge along the Lower Meghna River is 90,000 m^3/s, and minimum flow is close to 4000 m^3/s. Time-series and reliable sediment data of the major rivers are available from the 1960s to the mid 1990s. About 80% of the sediment entering into the Meghna estuary is silt and clay, and the rest is fine sand (Table 9.2).

Table 9.2 Mean annual suspended loads, based on sediment measurement of FAP 24 from 1994 to 1996

Period	Type of sediment	Jamuna	Ganges	Padma
1994–1996	wash load (Mt y^{-1})	280	560	720
	suspended bed load (Mt y^{-1})	125	75	230
	total (Mt y^{-1})	405	635	950

Source CEGIS (2010)

The delta building processes were initiated in the early Holocene (10,000 years, BP). During the period, the main courses of the Ganges, Brahmaputra, and Meghna shifted several times, followed by shifting of the active estuaries at different locations. The sediment carried by the Ganges, Brahmaputra, and Meghna Rivers has contributed to the present size of the delta which is about 100,000 km^2 (Goodbred and Kuehl 2000a). A brief historical account is presented below.

Millennial Time-Scale

Several studies on river evolution in the Holocene period were carried out by Fergusson (1863), Williams (1919), Umitsu (1993), Goodbred and Kuehl (2000a and 2000b), and Allison et al. (2003). Among those, the most comprehensive account of the development of the Ganges–Brahmaputra (GB) delta from the late Quaternary and extending through the Holocene was presented by Goodbred and Kuehl (2000a and 2000b); Allison et al. (2003); Kuehl et al. (2005). Their account was based on borehole data collected for the studies, as well as from Umitsu (1993) and other sources as mentioned above. The paleo-geographic maps show the continuous shifting of the Ganges River from west to east and periodic avulsions of the Brahmaputra River between the east and west sides of the Madhupur Tract during the Holocene. The latest avulsion of the Brahmaputra from west to east occurred about 3,000 years Before Present (BP). At the millennium time-scale, locations of delta building and the estuaries of Ganges and Brahmaputra shifted from one place to other, sometimes operating together (GB1 in Fig. 9.2), sometimes separately (G1, G2, G3, B1, B2 in Fig. 9.2).

Centennial Time-Scale

Studies of old maps such as Rennel's (1776) and Tassin's map (1840) illustrate a series of changes of the river courses at the end of eighteenth and early nineteenth centuries: avulsion of the Teesta River from its old course along the Atrai River to its present course, initiation of avulsion of the Brahmaputra through the Jamuna River, and subsequent diversion of the combined flow of the Ganges and Jamuna into the Meghna at Chandpur. By the early nineteenth century, the flow of the Brahmaputra joined with the Ganges at Aricha and flew in a southeast direction as the Padma up to Chandpur where it met with the Meghna River. These latest changes resulted in one inlet into the Bay of Bengal for fluvial inputs, instead of the earlier two separated inlets of Ganges and Lower Meghna. This combination of the two rivers initiated several successive changes in the estuary. In 1776, the Lower Meghna took a sharp turn to the east, keeping Bhola and Hatiya islands at its right bank, followed downstream by a right turn and flowing along the west flank of Sandwip. These islands divided the

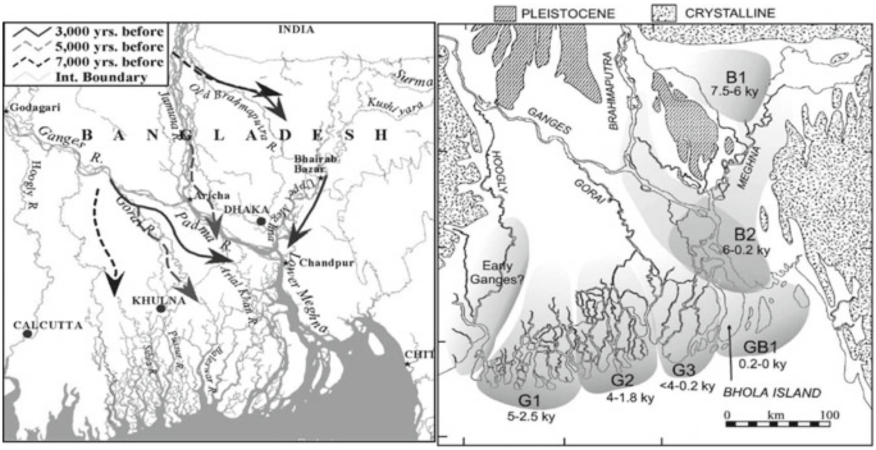

Fig. 9.2 Map of (A) Paleo-geographic map after Goodbred and Kuehl (2000a) and (B) the Pathways and timing of the phases of late Holocene growth of the lower delta plain associated with the Ganges (G1, G2, G3), Brahmaputra (B1, B2), and Combined Ganges–Brahmaputra (GB1) after Allison et al. (2003)

Lower Meghna into three distributary channels such as the Hatiya, Shahbajpur, and Tetulia channels (Fig. 9.3). Like any other tide-dominated estuaries elsewhere in the world, the Meghna estuary also demonstrates its typical channel-island sequences.

In 1776, the Ganges used to flow along the west flank of Bhola island, but gradually abandoned this channel by 1840, resulting in sedimentation of the old course. The sudden increase of flow in the Lower Meghna River due to the diversion of Ganges flow increased the erosion along the east flank of Bhola and west flank of the Hatiya. The most dramatic event in the last 242 years is the occurrence of enormous landslides in the Himalayas due to 1950 Great Assam Earthquake. Most of this sediment traveled through the Brahmaputra, Jamuna, Padma, and Lower Meghna Rivers before entering into the Bay of Bengal. It resulted in a net accretion of 1200 km^2 in the Meghna estuary from 1943 to 1973, and the abandoning of the main distributary channel Lower Meghna caused the diversion of its flow and sediments through the Shabazpur channel. During this period, several islands became a part of main land.

Bhola, Hatiya, and Sandwip were oval shaped islands, during the times of Rennels (1776) and Tassins (1840). Later, Bhola and Hatiya islands turned in southwestly direction with a curved elongated shape to the south. This development continues till date. The oval shape of Bhola and Hatiya also turned into elongated ones (Fig. 9.3) The southern tips of the Bhola and Hatiya were very close from 1776 to 1840, but by 1943 Hatia had migrated nearly 25 km south and continued moving further south during the next 77 years.

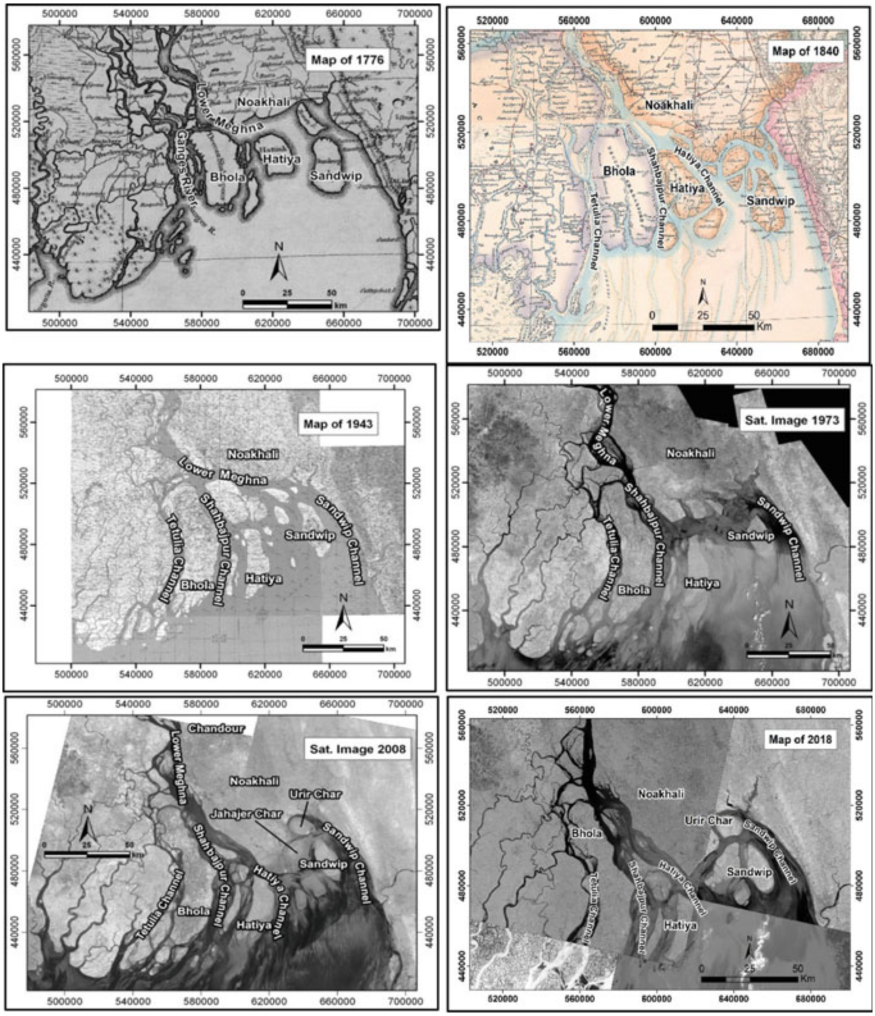

Fig. 9.3 Historical development of the Meghna estuary

Decadal Scale

During the last seven decades, the morphological metamorphosis of the estuary was largely dominated by the sediment generated by the 1950 Assam earthquake. Fine sediment traveled quickly and entered the Meghna estuary within a few months to a few years, without noticeable disturbance of the river morphology (Sarker and Thorne 2006 and 2009). Impacts of fine sediment were enormous in the Meghna estuary with a net accretion of land of 1200 km^2 until 1973. The coarser fraction (sandy bed material) traveled as sediment wave modifying the river morphology on its way. Sarker and Thorne (2009) estimated that coarser sediment took more than 50 years to travel from Assam to the Bay of Bengal. The changes from 1943 to 1973 are very remarkable. The course of the Meghna River at the east of Bhola Island was abandoned, resulting in the shifting of flow to the Shahbajpur channel. The Hatiya Channel was separated from this channel in the north of Hatiya Island. A very large land mass accreted to the south of Noakhali, Bhola, and Patuakhali. The enormous change during these 30 years is reflected in annual land accretion of up to 40 km^2. During the following decade, the annual rate of net accretion dropped sharply to 10 km^2/y; from 1984 to 1996, net accretion increased to 30 km^2/y; net accretion dropped again to 10 km^2/y from 1996 to 2008; further dropped to 8 km^2/y from 2008 to 2018. Sarker et al. (2011) attributed the first peak to the input of huge amounts of fine sediments immediate after the 1950 earthquake, while the second peak from the 1980s to the 1990s can be attributed to the arrival of the sediment slug in the estuary.

Prevailing Morphological Process of the Estuary

Process of Sediment Dispersion

Sediment distribution process in the estuary is mainly governed by the sediment characteristics and quantity, tidal range, waves, and the estuary planform and geometry (Palinkas et al. 2006; Bird 2008). Seasonal variation of fresh water input into the estuary ranges from 20 to 30 times, a similar range to that of sediment input. Most of the river-borne sediment enters the estuary during the few months of the summer monsoon. A major part of the sediment, especially the finer fraction, takes temporary residence in the zone of the turbidity maximum, which is close to the southern limit of the Shahbajpur channel (Sokolewicz and Louters 2007). The turbidity maximum generally occurs in the low salinity zone and shifts its location with the changes in flood discharge (Grabemann et al. 1995). The temporary storage of sediment during the monsoon in the zone of the turbidity maximum is the main source of sediment redistribution during the dry season.

Generally, tidal asymmetry is an effect of shallow water, which reduces the flooding period and increases the ebbing period. The shorter period generates high flow velocity during the flood tide and longer period generates low flow velocity in the shallow estuary. Differential flow velocities and longer time of high slack water bring the sediment maxima to the zone of sedimentation. Tidal asymmetry process cannot be active in presence of fluvial flow during dry season.

Tidal flow in the Meghna Estuary, as obtained from a mathematical model and field observations, showed that a part of the fresh water that enters through the Shahbajpur and Hatiya channels makes nearly a u-turn and forms loop-type circulations around Sandwip, Urir Char, and Jahajer Char (Fig. 9.4). Based on the MES II (2001) and Sokolewicz and Louters (2007), the relative importance of river and tidal flow with respect to sediment discharge has been drawn on satellite images of

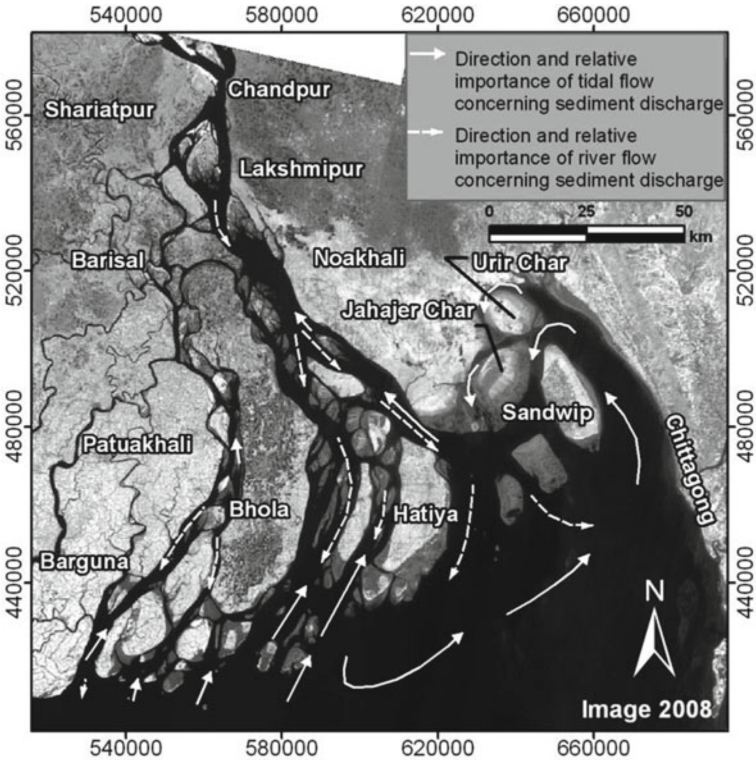

Fig. 9.4 Direction and relative importance of river and tidal flows in influencing sediment discharge (based on Sokolewicz and Louters 2007)

2010 (Fig. 9.4). It shows the tidal circulation and relative strengths of flooding and ebbing and subsequent sedimentation in the northeastern part of the estuary.

Processes of Land Formation

In the estuary, the process of land formation becomes visible when a bar (composed of fine sand, silt, and clay) emerges during low tide. Time-series analysis of satellite images shows the land formation process in different parts of the estuary. Initially, elevation of the bar is very close to, but higher than, the average low tide level. Over time, the elevation increases and the coverage of the bar surfaces changes (Fig. 9.5). It is first colonized by Uri-grass (Portaresia coarctata). In most cases, the Bangladesh forest department transplants mangroves at a certain stage of development of the bar. After rising to a certain level, very close to the average high tide (depending on the prevailing tidal range), mangrove forests dominate the land surface and people start to settle there. Tidal variation differs throughout the estuaries, which causes different

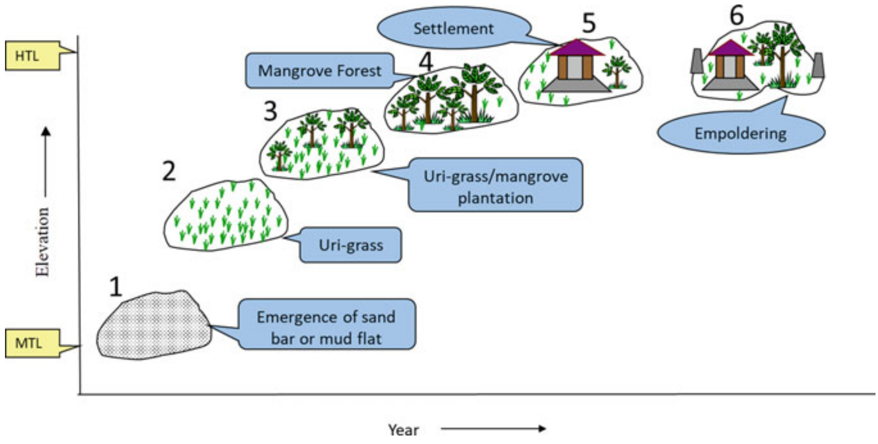

Fig. 9.5 Process of land formation in the Meghna estuary. *Source* Sarker et al. (2011)

Table 9.3 Time required for land development at different locations in the Meghna estuary

Location	Dominating process	Mean tidal range (m)	Time required for land development (year)
Outfall of Tetulia channel	Marine	2	22
Shahbajpur channel	Mixed energy	2	12
South of Noakhali	Mixed energy	3	12
Urir Char	Marine	6	16

elevation of islands. Time required for land development from its initial emergence to its inhabitation also varies depending on the availability of sediment and favorable environment for sedimentation.

Time required for development of land from its first emergence above low tide level to being fully covered by mangrove forests or the initiation of settlements varies from place to place (Table 9.3). The fastest land development as observed from time-series satellite imagery is 8 years within the Shahbajpur channel.

Processes of Erosion/Accretion in the Estuary

Morphological processes of estuaries are frequently disturbed by different natural hazards within the basin area of the contributory rivers (Goodbred et al. 2003). Island or coastal chars are one of the important components of an estuary, the morphology

Table 9.4 Comparison of erosion and accretion rates from different studies (MES II 2001)

Length of study period (years)	Period of study	Net change for period (km^2)	Rate of change ($km^2\ y^{-1}$)	References
220	1776–1996	+2187	9.9	EGIS (1997)
192	1792–1984	+1346	7.0	Allison (1998)
144	1840–1984	+638	4.4	Allison (1998)
23	1940–1963	+279	12.1	Eysink (1983)

Source MESII (2001)

Table 9.5 Comparison of erosion and accretion for the current study

Length of study period (years)	Period of study	Net change for period (km^2)	Rate of change ($km^2\ y^{-1}$)	Reference
64	1776–1840	+950	14	
103	1840–1943	−303	−3	
30 11	1943–1973 1973–1984	1200 110	40 10	Sarker et al. (2011)
12 12	1984–1996 1996–2008	360 120	30 10	

of which responds to the changes of the estuary. Prior to understanding the morphological processes of island chars, it is necessary to understand that of the overall estuary.

Erosion and accretion patterns in the Meghna estuary have been studied in the past by several agencies and researchers, including Eysink (1983), EGIS (1997), Allison (1998), Sarker et al. (2011), and MES II (2001). A review of historical maps, such as the Rennel's map (1776), the Commander Lloyd' chart (1840), Tassin's map (1840), topo map (1943), and time-series satellite images (since 1973) suggest that accretion has been the dominant process during the last 242 years in the coastal areas of Bangladesh (see Tables 9.4 and 9.5 and Fig. 9.7). The data update for this study found net erosion of 3 km^2/y for a period of 103 years between 1840 to 1943. The information of EGIS (1997) and Allison (1998) presented in Table 9.4 is split into different periods. As Sarker et al. (2011) showed in his study (refer to Table 9.5 and Fig. 9.7), in both centennial and decade scales, the result is net erosion from 1840 to 1943. This study estimated erosion and accretion rates for the period 1943–2008 (Fig. 9.6 and Table 9.5). During this period, the net accretion was 1200 km^2. Abandonment of the Lower Meghna caused huge accretion and merging of several island chars. On the other hand, diversion of flow from the Lower Meghna into the Shabajpur caused 430 km^2 erosion of the east part of Bhola Island (Fig. 9.6).

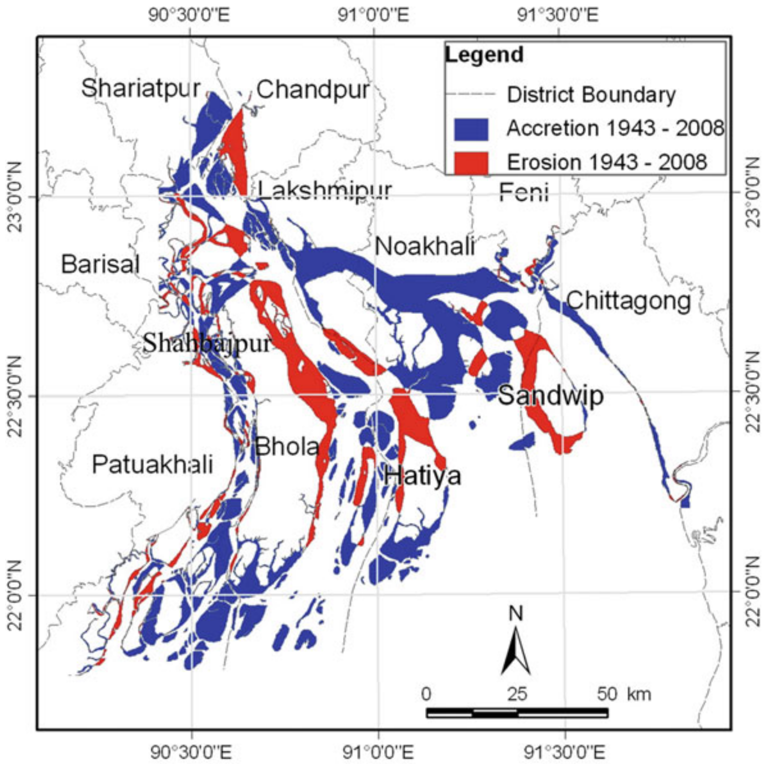

Fig. 9.6 Erosion/accretion in the Meghna estuary from 1943 to 2008

Erosion/Accretion Processes of the Islands/Coastal Chars

The island chars in the Meghna estuary have various sizes, shapes, and elevations. The average elevation of an island's land surface corresponds to the average height of the daily maximum tide level. There are four major coastal chars/islands in the Meghna estuary namely Bhola, Hatiya, Sandwip, and Monpura. All are more than 242 years old. Changes in surface area and shore line retreat over time are presented in Figs. 9.8 and 9.9. The following paragraphs describe the dynamic behavior of these islands. Every year the shore lines of these islands retreat or advance. Fluvial flow, tidal residual flow, and geometry of the islands and shorelines determine the locations of retreat/advance. The dynamics of the islands are derived from the rate of shoreline migration along the outer boundary and age of different parts of the islands (Figs. 9.8, 9.9, 9.10 and 9.11).

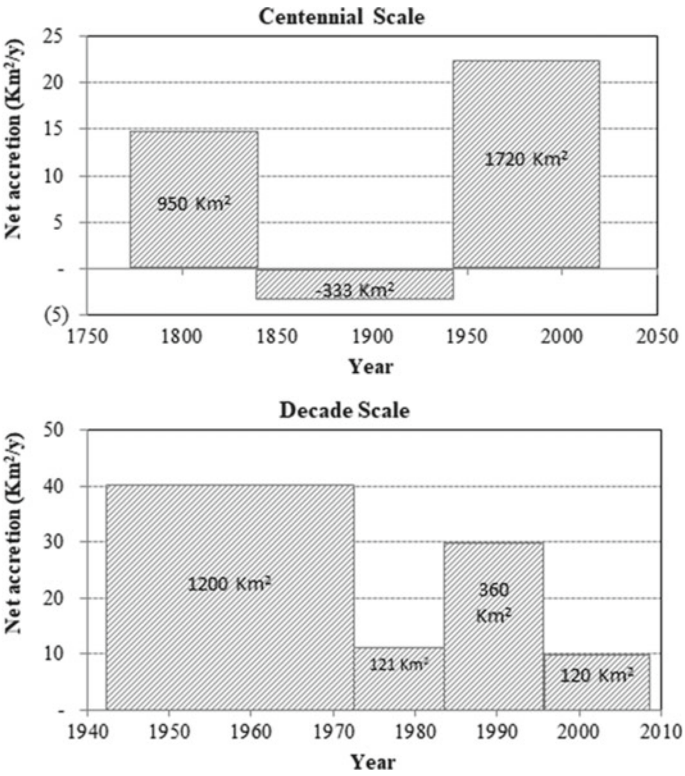

Fig. 9.7 Net accretion in centennial and decade scale

Bhola

Centennial scale (1776–2018)

Bhola is the largest island, presently 1340 km^2, which varied from 895 km^2 in 1776 to 1533 km^2 in 1973. From 1776 to 1840, the size of the island increased from 895 to 1392 km^2 with net accretion of around 500 km^2. In comparison, the net accretion in the whole Meghna estuary was 950 km^2. A major contributor was the sedimentation in the abandoned course of the Ganges, along the west flank of Bhola. From 1840 to 1943, the accretion amounted to 813 km^2 along the old course of the Ganges (Tetulia Channel) and the elongated southern part. At the same time, erosion resulted in the loss of 631 km^2 along the right bank of the Shajadpur channel. From 1943 to 2018, 432 km^2 eroded along the right bank of the Shajadpur channel while 398 km^2 accreted.

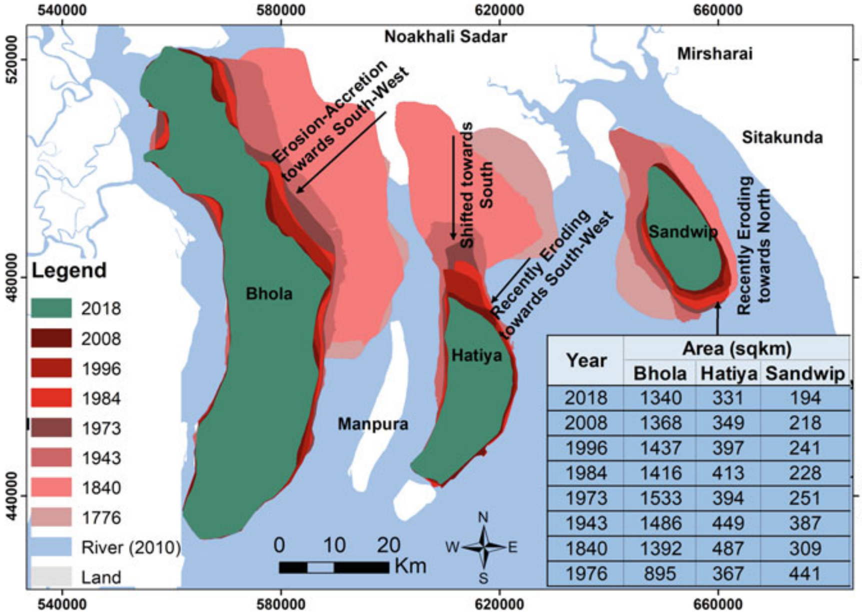

Fig. 9.8 Changes in surface area and shore line retreat of Bhola, Hatiya, and Sahdwip

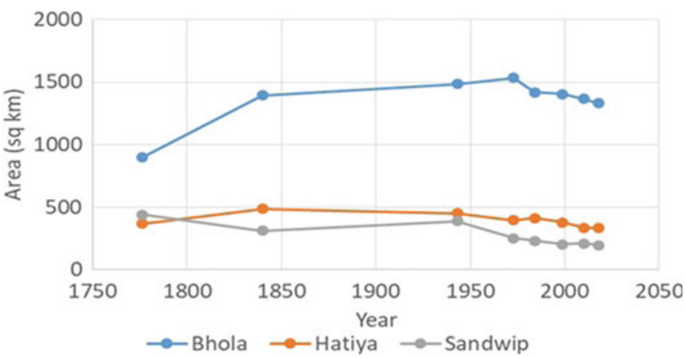

Fig. 9.9 Changes of area of Bhola, Hatiya, and Sandwip over time

Decadal scale (1943–2018)

Due to the abandonment of the Lower Meghna distributary channel, all fluvial load was diverted to the Shabajpur channel. To accommodate the additional fluvial inputs, the channel enlarged in width and depth, which resulted in a land loss of about 199 km^2 land along the northeastern and eastern flank of Bhola. Accretion mainly concentrated in the south of Bhola elongating the island in south-west direction.

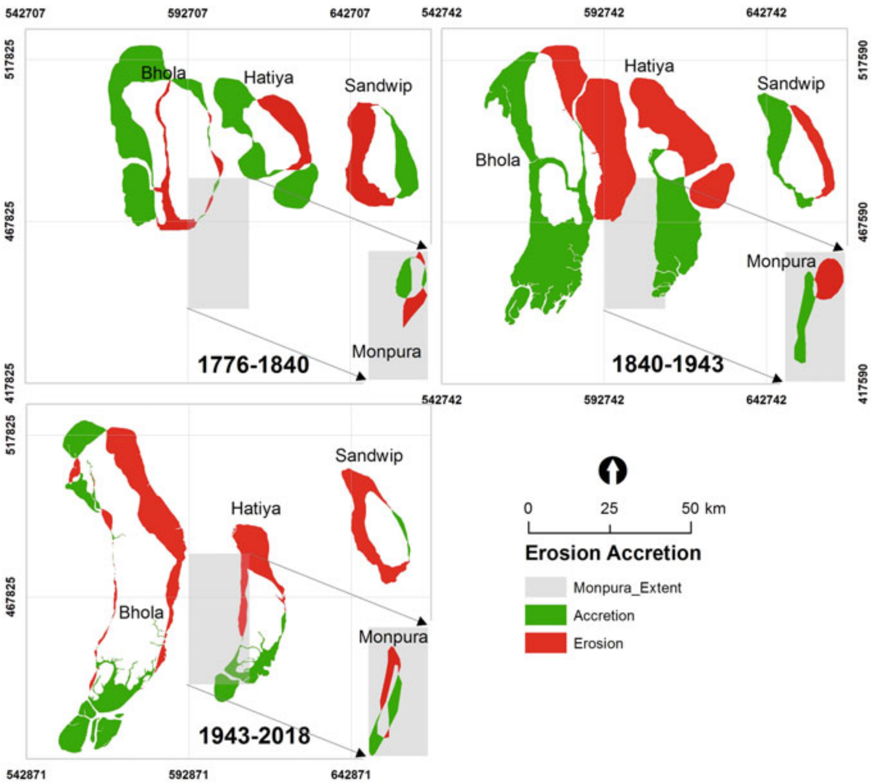

Fig. 9.10 Centennial scale erosion/accretion of the Island

Hatiya

Centennial scale (1776–2018)

Hatiya is a north–south aligned island about 36 km long, 9 km wide with a land surface area of about 330 km^2. This area is the lowest observed over the last 242 years. Its largest size was 487 km^2 in 1840. The Shahbajpur channel flows along the western margin of Hatiya island and the Hatiya Channel along its north and east boundary. From 1776 to 1840, Hatiya Island eroded 137 km^2 along the interface of the Hatiya channel and Hatiya Island, but gained 344 km^2 due to siltation of the Shabajpur channel at the west flank of the island. From 1840 to 1943 along the north-east margin, 487 km^2 eroded, 1.5 times of the present area of Hatiya, mainly because of enlargement of the Hatiya channel. During the peak accretion from 1943 to 1973, the main land of Noakhali/Lakshmipur propagated southward and pushed the Hatiya channel seawards.

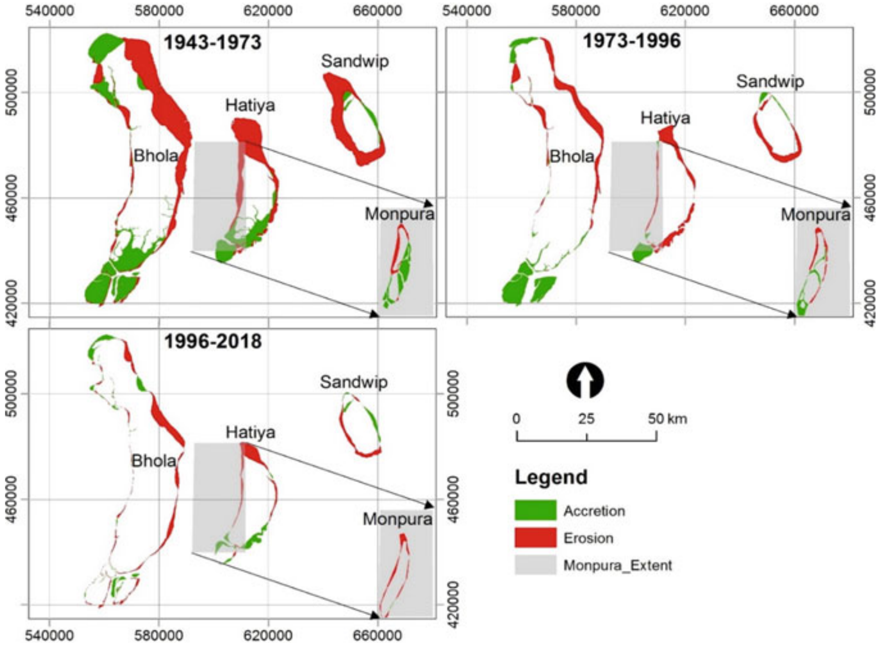

Fig. 9.11 Decade scale erosion/accretion of the islands

Decadal scale (1943–2018)

The southward progress of the main land and with it the Hatiya channel caused 7 km southward migration of the northern tip of Hatiya Island from 1943 to 1973 and shoreline erosion of 78 km^2. Till today, southward migration of the north margin continues. Both east and west flanks of the Hatiya Island are eroding due to the widening of the Shababajpur channel. This is compensated by accretion in the south developing the Hatiya Island in a southwestly direction.

Sandwip

Centennial scale (1776–2018)

The maximum size of this island was 440 km^2 in 1776, while the present size is 194 km^2, the smallest size in the last 242 years. The length of the island is now 21 km and its width is about 9 km. Sandwip Island eroded 224 km^2 and accreted 111 km^2 from 1776 to 1840. The Hatiya channel was the main inlet of fluvial input, was the western shore of Sandwip Island (Fig. 9.3), and caused shoreline erosion along the west flank of Sandwip. During the century from 1840 to 1943, high accretion occurred along the right flank of Sandwip as the Hatiya channel was declining in favor of the Sandwip channel. This then caused erosion along the east flank of Sandwip. Progradation of the main land after the 1950 earthquake, pushed the north boundary of Sandwip about 10 km in southeastly direction. Later Sandwip lost the direct connection with fluvial inputs. Erosion/accretion process along the north, west, and south margins of the island continues intermittently mainly driven by circular tidal flow and wind wave.

Decadal scale (1943–2018)

Erosion was very high along the north, west, and south margins as much as 200 km^2 during the 30 years from 1943 to 1973. During this period, the Meghna channel closed, and erosion and accretion processes at Sandwip were more and more determined by the tides.

Monpura

Centennial scale (1776–2018)

Monpura is a small island having an area of about 120 km^2, situated in the Shahabjpur Channel, between Bhola and Hatiya islands. It is a narrow and elongated island, the width and length of which are 4 km and 30 km, respectively. It changed its shape and size over time. In 1776, it was an elongated island, which turned into an oval-shaped island by 1840. Later on, it turned into an elongated shape again. From 1776 to 1840, 45 km^2 of the south part of Monpura Island eroded, while 45 km^2 were gained in the western part of the middle section. From 1840 to 1943, the island moved to the south-west. From 1943 to 1973, 48 km^2 were eroded from the north, and 61 km^2 were accreted in the southern and eastern part. Being a small island, erosion and accretion occurs easily.

Decadal scale (1943–2018)

Decadal scale shifting of the Monpura is not significant. Net accretion from 1943 to 1973 was about 30 km^2 in the southern and eastern part of the island. Erosion in the north and east, and accretion in the south and west, caused net accretion of 6 km^2 in between 1973 and 1996. 16 km^2 erosion occurred all around the island from 1996 to 2018 (Table 9.6).

Urir Char

Urir Char is a new island that became visible on 1973 satellite images. Since its emergence, it started to migrate northwaard. The rate of erosion in and around Urir Char varied within a small range from 4.5 to 7 km^2/y over different periods from 1973 to 2008. During the same period, the rate of accretion of different time periods varied at a wider range: from 11.5 to 22.5 km^2/y, and the corresponding rates of net accretion varied within a range of 6.3–15.3 km^2/y. The rate of net accretion has increased from 12.5 to 15.3 km^2/s in the last one and a half decades from its previous rate of net accretion of 6.3 to 7.5 km^2/s. From 1973 to 2008, the total eroded land area was 198 km^2 while 522 km^2 accreted.

Table 9.6 Erosion/accretion, net accretion of Bhola, Hatiya, Sandwip, and Manpura Island

Island	Parameters	Area in km^2		
		1776–1840	1840–1943	1943–2018
Bhola	Erosion	113	631	432
	Accretion	536	813	398
	Net accretion	423	183	*−34*
Hatiya	Erosion	137	487	188
	Accretion	344	396	140
	Net accretion	207	*−91*	*−48*
Sandwip	Erosion	224	93	190
	Accretion	111	169	13
	Net accretion	*−113*	76	*−177*
Monpura	Erosion	46	88	48
	Accretion	51	87	61
	Net accretion	5	*−2*	14

Migration and Elongation of Islands

The migration of islands, Bhola, and Hatiya as an example is presented in Fig. 6.10. The initially oval-shaped island in 1776 and 1840 (Figs. 6.3 and 6.10) elongated and migrated to the south-west. Due to changes in number and locations of inlets for fluvial inputs, distributary channels had to adjust with the new situation. Abandoning, declining and enlarging of distributary channels determined the morpho-dynamic of the islands for a particular period.

The topo map of 1943 and satellite images from 1973 to 2018 show how the southern tips of Bhola, Hatiya, and Sandwip started to bend in southwestern direction. The trajectory of migrations of the southern tips point toward the Oceanic Trench (close to Hiron Point). Through two deep marine channels, Kutubdia channel and Oceanic Trench (Swatch of No Ground) the tide travels quickly and reaches Cox's Bazar and Hiron point at same time (MES II 2001). The influence of the tide coming through the deep Kutubdia channel influences the Sandwip channel, which was not prominent. On the other hand, the tide coming through the Oceanic Trench might have exerted some limited influence on the southern tips of Bhola and Hatiya Island from 1776 to 1840. Whenever the southern part of Bhola and Hatiya entered into the tide influenced zone, they continued to bend south-west ward. This process elongated Bhola Island to 100 km and and narrowed it down to 13 km. Similar changes occurred for Hatiya, which started to bend close to its southern tip in 1840. The pattern of the migration and elongation is similar to Bhola, but the magnitude different. The southern tip of Bhola migrated more than 50 km, while that of Hatiya 30 km. Unlike Bhola and Haiya islands, Sandwip did not participate in the migration processes. Its southern tip varied only within a few kilometers during the last 242 years.

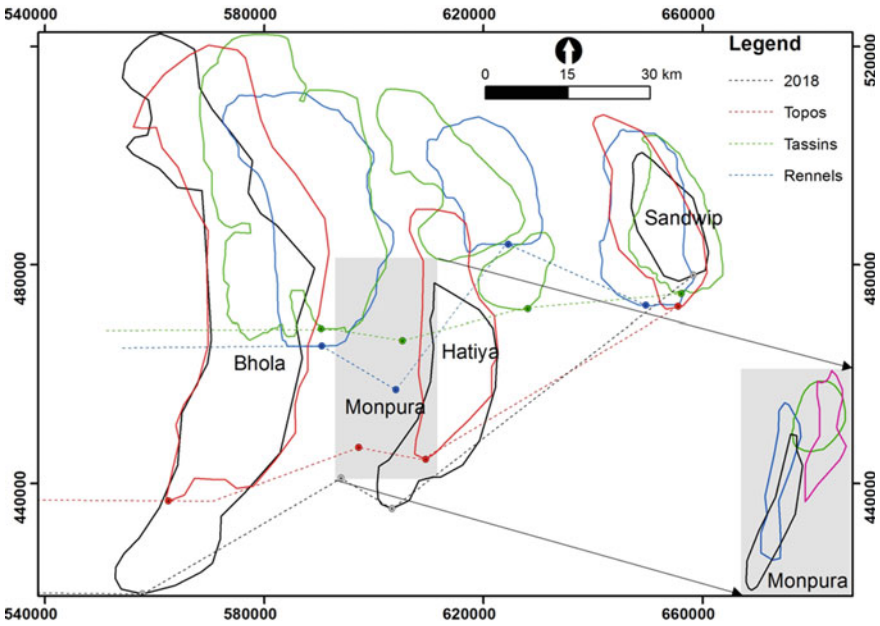

Fig. 9.12 Century-scale stability of the islands and delta progradation

Stability of the Islands

The stability of the islands has been assessed by superimposing historic shorelines and thus determining the age of different parts of the island (Fig. 9.12). Considering size and length, Bhola is the largest island. Since 1840, its southern tip migrated 50 km. Nearly, 50% of the present island is more than 75 years old and only 17% older than 242 years.

Although Hatiya Island is more than 242 years old, the present island has no overlap with the island in 1776 and 1840. The oldest part of the present Hatiya Island is more than 45 years but less than 75 years old. Among the three islands, the stability of Sandwip is highest: 70% of the island is more than 242 years old.

Identifying the Drivers

Most of the drivers might be several hundred or even thousand kilometers away from the islands. There might be no direct link between the drivers and event occurrences. For example, the last avulsion of the Brahmaputra caused the abandonment of the lower Ganges reach—within the estuary along the right flank of the Bhola Island. There exist several interlinked processes before the effect of the avulsion becomes visible. Before identifying the driver, one should be aware of interlinked processes and the final visible representation in the system.

During the period from 1776 to 1840, major events within the estuary were net accretion of 950 km^2 of land (equivalent 14 km^2/y), abandonment the inlet or lower reach of the Ganges, and subsequent enlargement of the second inlet, the Lower Meghna River. The avulsion of the Brahmaputra around 1800 can be treated as the main driver for all three events. Between the drivers and events, there were no direct spatial and temporal connections. During this period (1776–1840), siltation of the old course of the Ganges along the right flank of Bhola caused the increase in size and westward migration of the island. On the other hand, enlarging of the Lower Meghna also widened the downstream distributary, Hatiya channel, and as a result, huge erosion occurred along the left flank of Hatiya Island and right flank of the Sandwip Island. Relevant for the changes in islands were the main drivers declining of the Ganges and enlarging of the Hatiya channel.

From 1840 to 1943, erosion was the dominant morphological process within the estuary. The reasons for this net erosion are not clear. Some of the processes activated in the previous decades might have continued for a few decades after 1840, and/or a certain relaxation process after huge net accretion from 1776 to 1840 might have played a role. In case of the islands, major events were the enlargement of the distributary channels Shahbajpur and Sandwip and subsequent decline of the Hatiya channel and elongation of Bhola and Hatiya islands. The southern tip of Bhola is migrated by 30 km and that of Hatiya by 15 km. Preliminary investigations show that the tide coming through the Deep Oceanic Trench influenced the flow direction through the Shahbajpur channel and therewith the shape of the three islands Bhola, Monpura, and Hatiya.

The period from 1943 to 2018 is different from its two preceding periods. Net accretion in the estuary reached 1700 km^2 in the next 75 years. The downstream reach of the Lower Meghna and its downstream continuation, the Sandwip channel, were abandoned. As a result, the fluvial inputs started to divert through the Shahbajpur channel. The main driver for the huge sedimentation and abandoning of the largest distributary is the 1950 Great Assam Earthquake. As a consequence of the diverted water and sediment flow into the Shahbajpur channel, it widened from 8 to 23 km by eroding the left flank of Bhola. The maximum observed shore line retreat from east to west was 9 km. Furthermore, the abandoning of a 6 km wide distributary channel resulted in the merging of several islands with the mainland such as Char Alexander, Ramgati, Char Gazi, Char Lakhi, and Char Jabbar. Progradation of the delta pushed the northern tips of Hatiya and Sandwip seaward by 13 km and 14 km, respectively.

Decadal Scale (1943–1973): Within the estuary, 1200 km^2 accreted and the lower reach of the Lower Meghna (acting as distributary channel) was abandoned (Fig. 6.6), which caused the widening of Shabajpur channel. Immediately after the 1950 Great Assam Earthquake, the silt and clay fraction of sediment (wash load) entered into the estuary within years. Consequently, this fine sediment is a main driver for the estuary. The abandonment of the former main distributary Lower Meghna altered the planform of Meghna estuary. In addition to natural changes, human interference also played a role. Two cross-dams were constructed in 1957 and 1964 to expedite the accretion processes. A number of islands became part of the mainland, pushed the northern tip of Hatiya and Sandwip to migrate 9 km and 12 km, respectively.

From 1973 to 1984, the net accretion rate dropped from 40 to 10 km^2/y. From 1984 to 1996, the rate of net erosion suddenly increased to 300 km^2/y. This event coincided with the entering of the sediment wave (Sarker and Thorne 2006 and 2009). All four islands reduced in size (Fig. 9.11) although the rate of net accretion in the estuary was very high. Land accretion occurred along the South Bhola and Patuakhali districts and the northeastern corner of the estuary.

The above analysis indicates that any large disturbance in the river basins can be felt in the estuary. Even though the behavior of the islands cannot directly be attributed to exogenous factors, experience with the past responses of the estuary to disturbance will help to predict the behavior of the islands in the future.

Impacts of Sea Level Rise and Anthropogenic Interventions

With the increase in sea level, the main impact on the estuary will be governed by the water and sediment input from upstream through the Ganges and Brahmaputra rivers. However, these two parameters are highly variable over time and strongly influenced by climatic (precipitation) and anthropogenic forces (Xu et al. 2007). Higher sediment flux is generally expected due to higher rainfall and temperature (Walling and Webb 1996; Hovius 1998; Zhu et al. 2008).

According to Palinkas et al. (2006) and Bird (2008), sediment trapping, an endogenic factor in the estuary, mainly depends on the amount and characteristic of the sediment, the characteristics of the tides, the channel geometry, and planform of the estuary. Residual flow/tidal asymmetry determines the location of sedimentation, which reduces the amount of sediment supply to the sea (Xu et al. 2007). In addition to natural factors, the extent of human interventions and their effects on the fluvial discharges of the Ganges and Brahmaputra rivers are also uncertain. A higher rate of discharge and sediment flux proportional to the increase of precipitation in the Ganges and Brahmaputra basins would seem to be a likely scenario for the coming decades. Brammer (2004) suggested that sediment deposition will raise the land in the coastal areas and the banks of the tidal and estuarine rivers at the same rate as the rise in sea level, if the rate of sea level rise is limited to a certain low range. However, flooding of the land behind the raised coastal land and higher river banks will increase due to ponding of rain water.

A study by CEGIS (2010) indicated that with a moderate sea level rise of 60–100 cm within the next 100 years, there would not be any transgression of the sea if the sediment supply remained the same. With sea level rise, estuary bed- and shore levels as well as riverbank elevations will increase. Due to phase lagging, the adjustment process will be more delayed the farther away any location is from the sea. Adjustment will be instantaneous at the estuary. The vertical accretion of land in the estuary would keep pace with the sea level rise. But the riverbank adjustment would have a phase lag depending on the distance from the bay. However, the major part of the tidal plain, embanked by poldering in Bangladesh will not receive any sediment and will suffer from increasing drainage problems until pump drainage is introduced. The formation of new land in the Meghna estuary would be continued at a lower rate, depending on the rate of sea level rise and sediment supply from upstream. The effects of climate change on coastal chars are further reviewed and discussed in Chap. 11.

Conclusion

To enhance the ability to predict the response of the system, the article identified the drivers of past events and assessed the role of the events and responses of the system to these events. The centennial scale events identified are: net accretion of 950 km during 1776 to 1840 caused by large amount of sediment entering the Meghna Estuary due to the avulsion of the Brahmaputra River; net accretion of 1700 km during 1950 to 2020 due to the landslides in the Himalayas generated by the 1950 Assam earthquake; and changes in size, shape, and location of the islands from 1840 to 2020, the main driver of which was the tide coming through the Oceanic Trench (close to Hiron point).

Analysis of the events during the time period between 1950 to 2020 allowed an understanding of the decadal scale events within this period. Net accretion of 1200 km occurred from 1950 to 1973, the main driver of which was high fine sediment input in the Meghna Estuary. Net accretion of 360 km occurred from 1984 to 1996 which was mainly caused by the sediment slug (sediment wave) in the estuary. During the periods from 1973 to 1984 and from 1996 to 2020, the estuary experienced much lower net accretion, and it may continue in the future if there is no major disturbance in the system.

Formation of an island from sandbars to mature mangrove forests or settlements takes 12 to 22 years which means it is a decade scale morphological process. Island formation takes less time in areas which are influenced by the fluvio-marine process and more time in areas dominated by the marine process.

Stability of the chars was assessed from their age. It was found that islands in areas under the marine system are more stable than islands in areas under the fluvio-marine system. The islands surrounded by the distributaries within the fluvio-marine system show a very dynamic behavior. Morphological changes such as char formation, migration, and erosion/accretion are higher in the fluvio-marine system than in the marine system.

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Chapter 10
The Soils of Charlands in Bangladesh

Hugh Brammer

Abstract There are significant differences in sediments and soils between the five river and estuarine char regions of Bangladesh: Teesta–Brahmaputra–Jamuna, Ganges, Jamuna–Ganges, Lower Meghna river and Meghna estuarine. The Brahmaputra–Jamuna and Ganges river sediments are predominantly silty, but the two regions upstream from the confluence of the two rivers also include significant proportions of sand. Brahmaputra–Jamuna sediments are noncalcareous, whereas Ganges sediments and combined Jamuna–Ganges sediments are calcareous. Meghna estuarine sediments are slightly calcareous and to varying degrees saline. Between 10 and 59% of sediments in the different char regions have developed into soils. Despite exposure to serious hazards of seasonal floods, land erosion and burial of riverine charlands by new sediment, and of salinity, local bank erosion and exposure to cyclones and storm surges on estuarine charland, all the regions are widely settled and used for the cultivation of site-adapted crops. Possible methods to increase economic production are reviewed, and a brief look is taken at possible future developments.

Keywords Soil types in charlands · Sediments · Brahmaputra–Jamuna and Ganges rivers · Crop production in charland · Bangladesh

Introduction

This chapter describes the major properties of the sediments and soils occurring in the five charland regions and the potentials and limitations for economic development in each region. Information is drawn from the author's long experience of soil surveys and agricultural development in East Pakistan and Bangladesh (Brammer 1996, 2012) and from the Bangladesh Flood Action Plan Charland Study (ISPAN 1993). First, the basic properties of charland sediments and soils are described. Soil fertility and crop suitability are reviewed in two following sections, and possible

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future developments are explored in the closing section. Simplified profile descriptions and selected analytical data are given for eight charland sediments and soil types are provided in Annex 10.1.

The five charland regions in the country are the Teesta–Brahmaputra–Jamuna, Ganges, Jamuna–Ganges, Lower Meghna river, and Meghna estuarine (see Fig. 1.2 Index Map of the Char Regions 2020/Chap. 1). These char regions have sediments of different kinds (see Table 10.1). The Teesta–Brahmaputra–Jamuna Floodplain char region has noncalcareous sediments of the Teesta and Brahmaputra rivers which have similar properties. The Ganges char region above the river's confluence with the Jamuna river has purely Ganges sediments which are calcareous. The Jamuna–Ganges char region between the Jamuna–Ganges and Ganges–Meghna river confluences includes mixed Brahmaputra–Jamuna and Ganges sediments.[1] Since the mean flow of the Jamuna river is about twice that of the Ganges river, the sediments in this region are mainly much less calcareous than those in the Ganges River Floodplain, but the proportions can vary from year to year depending on the relative severity of Brahmaputra–Jamuna and Ganges river floods. The Lower Meghna River Floodplain includes sediments similar to those in the Jamuna–Ganges Floodplain region, but it is tidal in the dry season and it becomes transitional to estuarine charland in the south. The Meghna Estuarine Floodplain includes mixed sediments from the regions upstream deposited under tidal conditions; they are to varying degrees saline. The Middle Meghna River Floodplain has been excluded from description because the char areas formed by the Brahmaputra river before its avulsion into the Jamuna river about two centuries ago are no longer active and the proportion of the region occupied by young char deposits is small.

In discussing char sediments and soils, it is useful to differentiate between soils in the broad agricultural sense, as mineral or organic materials in which plants can grow, and soils in the technical sense, as mineral or organic materials whose original properties have been significantly changed by environmental factors such as climate, vegetation, aeration and drainage over time. The successive stages in the formation of Bangladesh's char sediments into soils are described in Brammer (1996; also, see Chap. 8). In Table 10.1, a distinction is made between alluvium and soils. Alluvium includes sediments which retain their original properties (except in top soils that have been disturbed by ploughing). Soils comprise sediments in which chemical and physical changes have significantly altered the properties of the original alluvium

[1] Post-independence hydrologists wrongly named this section of the river the Padma. The ancient Hindu name Padma belonged to the old course of the Ganges river through Bengal, the lower part of which ran down what is now the Arial Khan river, as is shown on maps made by Rennell 250 years ago. The section of the present river along the boundary between the former Dhaka and Faridpur Districts did not exist at that time. It developed when the Brahmaputrachanged course into what is now the Jamuna river sometime after 1787 and the combined Jamuna and Ganges flow broke into a minor river, the Kirtinasa, to join the Meghna river opposite Chandpur. This section of the Ganges river is still named Kirtinasa on subsequent Survey of India, Pakistan and Bangladesh maps. The river is first shown in this channel on a map made by Tassin in 1840.

Table 10.1 Proportions of alluvial sediments and soils in Bangladesh's riverine and estuarine floodplain regions in textural classes

Floodplain region	Total area km^2	Water area km^2	Land area km^2	Alluvium % of land area			Soils % of land area		
				Sand	Loam	Clay	Sandy	Loam	Clay
Teesta–Brahmaputra–Jamuna	4615	1015	3600	36	35	0	0	28	1
Ganges	1365	341	1024	24	56	9	0	5	5
Jamuna–Ganges	1211	375	836	7	32	9	0	26	26
Lower Meghna River	292	356	435	9	67	4	0	6	14
Meghna estuarine	4968	NR	4,958	0	41	0	0	59	0
All regions	12451	2,087	10,853	(29)	(39)	(3)	(0)	(23)	(6)

Note Source Brammer, 2012. Water was not recorded separately in the Meghna estuary because it includes a substantial sea area. Therefore, the totals in the water column and in the alluvium and soils texture columns relate to the land area in the riverine regions. Percentages have been rounded to the nearest whole number. The data relate to surveys carried out in the 1960s.

over time (technically to a depth exceeding 25 cm). Table 10.1 also shows the proportions of the sediments and soils occupied by sandy, silty and clay materials in each charland region, referring to their subsoil properties.

By contrast with the char areas, the meander floodplains adjoining the major rivers are predominantly occupied by developed soils, with alluvial sediments occupying only minor areas alongside tributary and distributary rivers. At the time of soil surveys made in the 1960s, undeveloped alluvial sediments occupied 11% of the total area of the Teesta Floodplain, 18% of the Brahmaputra–Jamuna Floodplains and 8% of the Ganges River Floodplain, which includes the Lower Meghna char region (Brammer 2012). Young sediments occupied 64% of the Young Meghna Estuarine Floodplain at that time, but subsequent erosion of older estuarine land suggests that young sediments might now occupy a greater proportion of this region.

Land erosion and deposition of new alluvium are more rapid on riverine char areas than they are in most parts of the Meghna estuary, and the proportions of sandy and silty sediments in an area can change between years depending on the severity of annual floods and their sediment loads; more sand is deposited in high floods than in years with average or low floods. Most river chars are eroded within 15–30 years of their formation; only small areas are apparently more than about 50 years old. There are no significant differences in physical properties and longevity between char formations adjoining riverbanks (so-called attached chars) and those in mid-river/island chars, but the differences in accessibility can influence settlement, human security and land use.

In contrast with riverine char areas, Meghna estuarine sediments are almost entirely silty and much land is centuries old; substantial parts of Bhola, Hatiya, Sandwip and the former Ramgati island are shown on Rennell's maps prepared over 250 years ago (Brammer 2012). In this region, old, deeply developed soils occupied 12% of the land at the time of soil surveys in the 1960s; young soils in which only the topsoil and sometimes the upper subsoil had been significantly changed from that of the original alluvium occupied 47%; and little-changed alluvium occupied 41%; (water was not included in the figures for this region given in Table 10.1, because it includes the sea area between the major islands). The regional areas and textural proportions given in Table 10.1 must be regarded as of indicative value only. There are two reasons for this. Firstly, the data are derived from soil surveys carried out in the 1960s, since when the areas of the char regions have changed due to land erosion and new sediment deposition (see Table 10.2).

Since the time of those surveys, the Brahmaputra and Jamuna rivers have tended to erode old floodplain land on their western side, and young sediments on the rivers' eastern sides have developed into soils and joined the Young Jamuna River Floodplain. These changes in the Brahmaputra–Jamuna river followed a major earthquake in Tibet in 1950 which caused huge landslides on Himalayan mountain sides in Assam which in turn greatly increased the sediment load in the Brahmaputra river, the sandy bed-load of which took about 50 years to pass through Bangladesh; the silt load passed quickly through Bangladesh, forming much new land in the Meghna estuary in the early 1950s (Brammer 2012). Secondly, the land areas and textural proportions within the riverine regions change annually, depending on the severity of

Table 10.2 Land accretion and erosion in the major rivers of Bangladesh

Char region	Erosion (ha)	Accretion (ha)	Gain/Loss (ha)
Brahmaputra–Jamuna	87,713	16,444	−71,269
Ganges	30,100	25,712	−4388
Jamuna–Ganges	41,650	7212	−34,438
Lower Meghna	90,079	103,003	+12,924
Meghna estuary	273,436	321,950	+48,514
All regions	522,978	474,321	−48,657

Source Adapted from Government of Bangladesh (2018). Data are for the period 1973–2010 for the Meghna estuary and for 1973–2013 for the other regions. The Jamuna–Padma region was named Padma in the original source

river floods: more land is eroded and more sand deposited in years with high floods than in years with lower floods. In the Meghna estuary, much old land on the old islands has been eroded since the 1960s, but more new charland has been formed than old land has been eroded (Brammer 2014). The data refer to dry season conditions, of course. In all five regions, most of the land is submerged by flowing river water during the monsoon season.

Sediments and Soils

The main difference between floodplain sediments and soils is that sediments comprise loose sand or stratified silty material, either throughout or below a cultivated topsoil, whereas the original sediment in soils has been broken up by roots and, in silty material, by alternate seasonal shrinking and drying to a depth exceeding that affected by ploughing, which has allowed physical and chemical changes to occur in the original material. Technically, therefore, soils have a subsoil with properties that differ significantly from those in an overlying topsoil and in the underlying substratum; the descriptions of Silty Jamuna Alluvium and Dhamrai soil series are presented in Annex 10.1, both of which occur on Jamuna river alluvium.

Exceptionally, sediments on some parts of the Meghna Estuarine Floodplain in which only the topsoil has significantly different properties from those in the underlying sediment have been included as soils in this chapter. That is because, in some areas of Meghna alluvium that may have been in place for over 50 years (and possibly for over 250 years on parts of Bhola, Hatiya and Sandwip islands), the repeated submergence by rainwater following puddling of the surface layer for the cultivation of transplanted aman paddy has removed lime and acidified the topsoil, but unaltered (or little-altered) stratified alluvium occurs immediately below the topsoil. In the Meghna Estuarine Floodplain region, therefore, separations have been made between unaltered sediments, young floodplain soils in which stratified sediment occurs immediately below a much-altered topsoil (Hatiya series), and old soils (Bhola series) in which both the topsoil and the subsoil have developed different properties from those in the original sediments.

There are, of course, transitions between sediments and soils as sediments gradually change into soils over a period of years; and there are also places where soils have later been buried by a thin layer of recent sediment which may differ in texture and other properties from those in the buried soil. Therefore, sediment and soil patterns can be complex in river floodplain regions. They can also change from year to year, depending on the relative contributions of sandy and silty sediments by floods in different years and in the areas eroded. As will be described below, the fertility of soils can also change over time.

The main differences between Teesta–Brahmaputra–Jamuna and Gangetic sediments and soils are that Teesta–Brahmaputra–Jamuna sediments and soils are noncalcareous whereas sediments and soils that include Gangetic alluvium are to some degree calcareous; most Meghna estuarine sediments and soils are to varying degrees saline as well. Gangetic alluvium contains a clay mineral (smectite) that has a higher nutrient-holding capacity than the kaolinite and illite clays in Teesta and Brahmaputra alluvium; it also gives Gangetic soils stronger shrink–swell cracking properties than occur in soils in the alluvium of other rivers in the country. Recent Teesta–Brahmaputra–Jamuna sediments are neutral to slightly alkaline in reaction throughout whereas older sediments and soils on those floodplains mainly have a near-neutral or acidic topsoil over a near-neutral or alkaline subsoil. Recent sediments that include Gangetic alluvium are mainly calcareous and alkaline throughout, but Gangetic soils and both young and old Meghna estuarine soils commonly have an acidic topsoil over neutral or alkaline lower layers. Examples of sandy and silty Brahmaputra–Jamuna alluvium, silty Ganges alluvium, two developed Ganges River Floodplain soils, and old, young and undeveloped soils in Meghna estuarine alluvium are described in Annex 10.1 at the end of the Chapter.

The main change from the original alluvium that has taken place in riverine soils is that both the surface layer and subsurface layer have changed properties. The topsoil has generally gained organic matter, lost clay relative to the subsoil, and has become less alkaline or even acidic: in the annexe, compare the descriptions of Silty Jamuna Alluvium and Dhamrai series (a young soil developed in Jamuna alluvium). Observe also that Kiranchi series, a basin soil on the combined Jamuna–Ganges Floodplain, has a much higher organic matter content than in Sara series, a ridge soil on the Ganges River Floodplain, and that both the topsoil and the upper subsoil are acidic and noncalcareous.

Soil Fertility

The natural fertility of charland sediments and soils is generally low. That is because of their low content of organic matter which can supply nitrogen to plant roots. The lime content of Ganges-derived sediments and soils reduces the availability of phosphorus to plant roots; and salinity in estuarine sediments and soils reduces or prevents plant root development and uptake of essential nutrients. Nonetheless, practical ways of cultivation and adding fertilisers can reduce these limitations in most areas, enabling adapted crops to be grown in sites least exposed to the natural hazards of destructive seasonal flooding, bank erosion and burial by new sediment in riverine regions, and seasonally varying degrees of soil and water salinity, exposure of marginal areas to bank erosion, and occasional destructive cyclones and storm surges in the estuarine region.

The concept of soil fertility is a highly complex subject in Bangladesh. It is made particularly complex in the country's charland soils because of the variations in sediment supply and soil development between areas and between years. The laboratory data given for each of the soils described in the annexe were for samples collected in the dry season from a small site within one field. Those data can only have indicative data; they are mainly useful for illustrating basic differences between soil series. As is explained in the following paragraphs, soil fertility can be highly variable within fields, between fields and over time.

Newly deposited sediment is low in organic matter. Deep-rooting grasses can gradually increase the organic matter content of sandy material over a period of 2–5 years, thereby increasing the availability of nitrogen and other nutrients to plant roots, but contents remain low because of the rapid oxidation of organic matter in such aerated sediments. That is especially so in cultivated sandy materials where the supply of organic matter from harvested crops is low. Silty sediments initially lack pores, and colonising plant or crop roots can only develop along the sides of cracks as the material dries out in the dry season. Ploughing or hoeing can increase aeration in the surface layer, but it takes time for roots to break up and aerate subsoil material, providing pores that are important for dry-season moisture supply; that is especially so in saline sediments. Over time, more organic matter tends to accumulate in silty and clay sediments and in soils that are seasonally flooded and stay wet for a greater part of the year than accumulates in sandy materials which remain aerated for much of the year. In both uncultivated and cultivated sediments and soils, organic matter only accumulates up to an equilibrium point where accumulation and oxidation balance each other.

In the sandy and silty sediments and soils that predominate in both riverine and estuarine char regions, organic matter contents generally remain moderate or low: see the analytical data for sandy and silty sediments given in the annexe. That is because of the rapid aeration of organic matter in sandy sediments and the removal of crop plant residues in cultivated soils, leaving only crop stubble, weeds and roots to remain and eventually decompose into humus. Soils in depression sites that stay wet for most or all of the year can accumulate more organic matter over time than soils on longer-aerated ridge sites: see the difference between the ridge soil Sara series and the basin soil Kiranchi series in the Annex.

Soils that are seasonally flooded also vary in fertility between the dry season when they are aerated and the monsoon season when they are flooded. That is because the chemistry of submerged materials is different from that of aerated materials. For example, top soils that are acidic or alkaline in the dry season become near-neutral in reaction when submerged, and clay destruction by the ferrolysis process during the period that sediments and soils are flooded releases nutrients into the soil solution (Brammer 1996). Algae and some natural plants growing in water during the wet season can add nitrogen, but the amounts added in the silty water that reduces the penetration of sunlight in charland areas may be less than occurs on adjoining floodplains that are flooded by rainwater through which sunlight can penetrate (Brammer 1996).

The factors reviewed above mean that the laboratory analysis of soil samples taken in the dry season and dried before analysis may produce results that are irrelevant for crops growing in the monsoon season (and for crops irrigated in the dry season). In modern times, of course, soil fertility can be changed by the addition of fertilisers, by cultivation methods and by differences in crops grown: for example, the cultivation of legumes can add nitrogen to soils; and flooding top soils by irrigating *boro* paddy in the dry season, by extending the period when soils remain wet, can change their natural organic matter contents and chemistry.

Soil fertility is variable on a local scale: within fields because of the irregular distribution of fertilisers and manures, but also because of differences caused by soil disturbance by field levelling, depth of ploughing and burrowing by soil animals; and between fields because of different practices by different farmers. In a detailed study of fertility variations in Dhamrai series, a Young Jamuna River Floodplain soil, in which top soils were sampled at 5-yard intervals along a 250-yard traverse crossing 15 fields, several 10 X 10-yard squares were sampled at 1-yard intervals and several 1-yard squares were sampled at 1-foot intervals, soil reaction ranged between pH 4.96 and 6.64, organic matter ranged between 0.65 and 1.38%, and available phosphorus ranged between zero and 16.45 parts per million (Brammer 2000).

Fertility also varies with time because of differences in fertiliser applications between seasons and between years, differences in crops grown, uptake of nutrients by crops during the growing season, leaching by rainfall, fixation of phosphorus by iron-hydroxide and lime, and, in the case of charland, because of differences in the amounts and texture of sediments added by annual floods. As was explained above, fertility also varies seasonally between periods when soils are aerated and when they are flooded, including periods when irrigated boro paddy fields are flooded. In saline soils, differences in salinity between years and within the year can also determine the availability of nutrients to plants. In nonirrigated estuarine soils that are only slightly saline, salinity gradually increases in the topsoil during the dry season as the soil dries out and can increasingly interfere with plant nutrient uptake.

For the reasons given above, (i.e. differences in fertility over time, between seasons, and between and within fields), fertiliser requirements are best determined by in-field trials by individual farmers for the crops that they grow (IRRI 2016 Sect. 7), not by soil testing.

Crop Suitability

This section discusses land use in char areas only in general terms (also, see Chap. 19). The range of crops grown on charland sediments and soils is similar to the range grown on adjoining floodplain soils of similar texture and depth of seasonal flooding. Farmers' crop choice and their use of inputs such as fertilisers depend mainly on their knowledge and experience of moisture availability in their fields, on their perception of the risks of cultivation in specific environments and on the ease or difficulty of access to markets where they can sell their produce.

Most charland areas are to some degree hazardous for settlement and crop cultivation. The risks of damage or loss of crops vary from area to area and from year to year. In the riverine regions, they include the risks of rapid flow of floodwater over chars; burial of fields by new sediment, especially serious when sand is deposited; exceptionally deep flooding in years with high floods; and loss of land by bank erosion. In the estuarine region, constraints include soil salinity in younger land areas and in older land areas following flooding by a saline storm surge; bank erosion in some old land areas; and exposure to occasional cyclones and saline storm surges in all areas. Cyclones and storm surges can also damage or destroy crops on the Lower Meghna River Floodplain. Poor communications and remoteness from markets can restrict crop choice, input use and yields to different degrees in parts of both riverine and estuarine regions. New silty alluvium may be cultivated in the dry season following new deposition in easily accessible areas close to rural markets, but be deferred for several years in more remote areas.

Crops suitable for sandy and light silty river char areas in the *rabi* season include sweet potato, groundnut, chilli, sorghum, millet (*kaon*), melon, pumpkin and bitter gourd. On more loamy materials, wheat, sorghum, *kaon*, *cheena*, onion, mustard, sesamum (*til*) and safflower (*kussum*) might also be possible. Such materials, especially sandy materials, would benefit from mulching with plant material, addition of organic manure and irrigation, as well as use of appropriate fertilisers (Brammer 1997). In the monsoon season, what can be grown will depend on farmers' perceived risks of crop damage or loss by floods, burial of fields by deposition of new sediment or loss of land by bank erosion. In relatively secure sites, conventional kharif crops of *aus* and aman paddy, jute and *mesta* can be grown according to expected depths of flooding, and they can benefit from appropriate use of fertilisers. On the highest sites, sugarcane might be possible, and bananas and summer vegetables could be grown on raised beds to reduce the risk of loss by floods.

In parts of estuarine areas where soils only become slightly saline in the dry season, rabi crops such as chilli, sweet potato, sorghum, *bajra*, *kaon*, sunflower, safflower and various legumes might be appropriate on soils where broadcast aus or broadcast aman was grown, but the puddling of top soils for transplanted aman cultivation makes conditions less suitable for these crops unless raised beds are made. Mulching of soils in the dry season can reduce moisture loss and salt accumulation in top soils. In the kharif season in estuarine regions, it is better to delay the application of nitrogen and potash fertilisers in fields where aus is grown until two or three weeks after the crop is sown, by which time the risk is less of the topsoil becoming saline if there is a lull in the rains. Transplanted *aman* is generally the most appropriate kharif crop in saline area where monsoon rainfall and seasonal flooding greatly reduce topsoil salinity; varieties that tolerate slight soil and water salinity can be grown where there is a risk of increased salinity before aman matures. In the least saline areas where irrigation water is also available, high value fruit and vegetable crops can be grown, preferably on raised beds that are also kept covered with a protective mulch. In both the rabi and kharif seasons, farmers' use of improved crop varieties and fertilisers will depend on their perception of the risk of crop damage or loss by floods, storm surge and salinity as well as by relative ease of access to markets: farmers do not grow crops; they grow takas.

Shallow groundwater is readily available in riverine regions to provide irrigation to crops in relatively secure areas, but it is only available in the oldest estuarine floodplain area on Bhola island. In riverine regions, hand tube wells can be used on sites where it might be too risky to invest in providing shallow tube wells (STW). Plastic pipes should be used to distribute water in order to minimise percolation losses in permeable soils. In the estuarine region, deep groundwater may be available for domestic use and crop irrigation—as it is for boro rice production in a project area on Noakhali mainland—but the cost of supplying this water is high, and it still needs to be determined whether or not such groundwater will be adequately recharged over time.

In all regions, more could be done to use more economical methods of growing rice: e.g. by the System of Rice Intensification (SRI) in which the crop is grown under dryland conditions, or by Alternate Wetting and Drying (AWD) in which the soil is alternately flooded and then the water level in the soil is allowed to fall to 15 cm below the surface, both of which methods greatly reduce the use of water and irrigation costs relative to conventional flood irrigation of paddy fields. In areas close to urban markets, yields of fruit, vegetables and spices could be increased and made more secure by cultivation on raised beds, addition of manure plus mulching, and hand irrigation. More could be done, too, to provide roof catchments to supply water for domestic use, especially in the estuarine region where the mean annual rainfall mainly exceeds 2500 mm.

Future Land Use

Contrary to popular opinion, Bangladesh lies in a region where the climate has not changed significantly to-date with global warming, nor have the frequency or severity of natural disasters such as floods and cyclones that can hazard lives and crop cultivation increased; in fact, the frequency of cyclones has decreased significantly in the last two decades (Brammer 2014, 2016).

A rising sea-level provides a greater risk to land and agricultural production in the Meghna estuary and the Lower Meghna River Floodplain (see Chap. 11). The long-settled and productive old charland in the Meghna estuary could erode at increasing rates as sea-level rises and it could become more susceptible to flooding with saline water, with resulting loss of settlements and agricultural land. Nonetheless, there could continue to be a net gain of land in the estuary with the continuing formation of new chars, but these will remain unsuitable for settlement and crop production because of salinity. Salinity of water in the Lower Meghna river in the dry season will advance further inland and could be increased in other seasons by saltwater flooding by storm surges.

In both estuarine and river char regions, planners need to look forward to a future when educated young people prefer to seek dry-foot employment in physically more secure regions, thereby creating labour shortages for manual agricultural work in insecure and remote char areas. In relatively more accessible parts of riverine and estuarine regions, it seems likely that agriculture will become increasingly mechanised. Intensive fruit and vegetable production must be expected to increase in the most accessible areas close to urban markets and to good road and water communications with major urban areas.

In more remote and insecure parts of riverine areas, settlements might be abandoned and alternative forms of land use will develop: possibilities might include dry season animal grazing; biomass production for fuel or other uses; fish farming; sand extraction for use in construction materials; and use of silty material for brick-making. In remote estuarine areas, possibilities include extending planting of mangrove trees for eventual timber production; dry season grazing by cattle or water buffaloes; and shrimp or fish farming.

More research studies are needed to ascertain the extent to which potential changes described above are actually happening in different char regions and to monitor changes that are identified. The practices described would have the advantage that they require fewer people to live in hazardous char environments, which is an advantage on both humanitarian grounds as well as in reducing the need for government and NGO expenditure on disaster preparedness and on implementing relief and rehabilitation operations after disasters occur. The ideal future to look forward to is forms of productive economic use of charland that do not require people to live in such hazardous environments. That makes a challenging research and development objective!

Annexe 10.1 Simplified Soil Descriptions

The terms and symbols used in the following soil descriptions are defined below.

Horizon: the layer described and sampled for laboratory analysis. They include:

A: the topsoil;

Ap: either the cultivated topsoil or only the plough pan (a subsurface layer compacted by ploughing soils when wet);

B: the subsoil in developed soils;

C: the substratum: material little or unaffected by soil-forming factors;

OM: organic matter;

N: nitrogen; and

$CaCO_3$: calcium carbonate (lime).

The soil depths given in inches in the original report descriptions have been converted to centimetres and rounded to the nearest whole number.

Sandy Jamuna alluvium

Tangail District

Sparse grasses. The field was planted with transplanted aman which had almost totally failed.

Horizon	Depth cm	Description
A	0–13	Loamy fine sand; light grey; loose when dry
C1	13–41	Fine sand; light grey; finely stratified; loose when dry
C2	41–71	Fine sandy loam; grey with greyish brown mottles; finely stratified; very friable moist

Laboratory data

Depth cm	Sand %	Silt %	Clay %	OM %	N %	pH	$CaCO_3$ %
0–13	78	18	4	0.17	0.02	8.0	Nil
13–41	93	5	2	0.05	0.01	7.6	Nil
41–71	58	37	5	0.17	0.02	8.0	Nil

Silty Jamuna alluvium

Tangail District

Aus-broadcast aman-maskali

Horizon	Depth cm	Description
Ap	0–13	Silt loam; grey with fine yellow–brown mottles; remnants of stratification; friable moist
C1	13–20	Silt loam; grey and dark grey-brown with distinct brown mottles; finely stratified; very friable
C2	20–56	Silt loam; olive-grey with faint olive-brown mottles; finely stratified; vertical cracks coated with reddish iron-hydroxide coats and fine roots

Laboratory data

Depth cm	Sand %	Silt %	Clay %	OM %	N %	pH	$CaCO_3$ %
0–13	10	72	18	0.86	0.04	7.3	Nil
13–20	14	78	8	0.47	0.02	7.5	Nil
20–56	2	80	18	0.92	0.04	7.4	Nil

Silty Ganges alluvium
District: Kushtia
Aus-rabi crops

Horizon	Depth cm	Description
Ap A1 C1	0–10 10–23 23–56	Silt loam; greyish brown and light brownish grey with fine yellow–brown mottles; massive; friable moist; moderately calcareous Silt loam; olive; friable; moderately calcareous Olive silt loam with few dark yellowish brown mottles; finely stratified; friable; moderately calcareous

Laboratory data

Depth cm	Sand %	Silt %	Clay %	OM %	N %	pH	$CaCO_3$ %
0–10	15	73	12	0.74	0.04	8.1	7.6
10–23	19	67	14	0.63	0.04	8.2	7.9
20–56	9	71	20	0.63	0.04	8.3	8.5

Dhamrai series: Young soil in Jamuna alluvium
Tangail District
Aus/jute-khesari/mashkalai/oilseeds

Horizon	Depth cm	Description
Ap1 Ap2 B C1	0–10 10–15 15–33 33–51	Olive-grey silt loam with fine dark brown and strong brown mottles; massive; friable; many fine pores and earthworm casts Grey silty clay stained dark brown along vertical root channels; coarse angular blocky; many fine pores and earthworm casts; friable Olive-grey silty clay loam with common light olive-brown mottles; coarse prismatic structure with thin patchy coatings on ped faces; many fine pores; friable Olive-grey silt loam with light olive-brown mottles; coarse prismatic with thin, nearly continuous coatings on ped faces; many fine pores; very friable

Laboratory data

Depth cm	Sand %	Silt %	Clay %	OM %	N %	pH	$CaCO_3$ %
0–10	14	61	25	1.16	0.07	5.7	Nil
10–15	4	54	45	1.34	0.08	6.6	Nil
15–33	5	61	34	0.98	0.06	6.7	Nil
33–51	5	71	24			6.8	Nil

Sara series: Young floodplain ridge soil in Ganges alluvium

Kushtia District

Aus–rabi crops

Horizon	Depth cm	Description
Ap1	0–10	Olive-brown silt loam; massive; friable; common fine pores
Ap2	10–18	Light olive-brown silt loam; weak subangular blocky; many fine pores; very friable
B	18–41	Olive-brown silt loam with few light brownish grey mottles; weak coarse prismatic structure with thin patchy dark greyish brown coatings on ped faces; many fine pores; friable
B3	41–69	Light olive-brown silt loam with few dark brown mottles; weak coarse subangular blocky structure with remnants of stratification in peds; many fine pores; friable
C1	69–84	Similar but stratified

Laboratory data

Depth cm	Sand %	Silt %	Clay %	OM %	N %	pH	$CaCO_3$ %
0–10	23	64	13	0.68	0.04	8.1	6.5
10–18	26	63	11	0.65	0.04	8.0	7.0
18–41	20	63	17	0.57	0.04	8.2	9.0
41–69	18	70	12			8.4	11.6
69–84	22	69	9			8.4	11.1

Kiranchi series: depression soil on the young floodplain adjoining the Jamuna–Ganges region

Dhaka District

Mixed aus+deep water aman—khesari/mustard

Horizon	Depth cm	Description
Ap1	0–10	Grey silty clay with distinct reddish yellow mottles; massive; firm moist; many fine pores
Ap2	10–18	Grey silty clay with yellowish red bacterial iron stains on ped faces and in pores; moderate subangular blocky structure; many fine pores; friable moist
B	18–28	Grey silty clay with reddish brown mottles; coarse and medium subangular blocky structure with patchy thin coatings on ped faces; many fine pores; friable moist
C	28–46	Grey silt loam; finely stratified within coarse plates; patchy coatings on vertical cracks and in pores; very friable moist

Laboratory data

Depth cm	Sand %	Silt %	Clay %	OM %	N %	pH	$CaCO_3$ %
0–10	8.9	40	51,1	2.18	0.11	5.4	Nil
10–18	6.6	42.2	51.2	1,77	0.12	5.9	Nil
18–28	6.8	47.3	45.8	1.07	0.07	7.7	2.4
28–46	7.4	71.9	21.6			8.2	6.3

Bhola series: old soil on the Old Meghna Estuarine Floodplain

Barisal District

Aus—transplanted aman—rabi crops

Horizon	Depth cm	Description
Ap1	0–10	Olive-grey silt loam with distinct yellowish brown stains along root channels; massive; friable
Ap2	10–15	Dark greenish grey silt loam with few distinct olive-brown mottles; massive; friable
B	15–43	Olive-grey silt loam with distinct dark yellowish brown mottles; weak coarse prismatic structure with patchy grey coatings on ped faces and in pores; friable
C	43–69	Olive-grey and olive-brown silt loam in bands, with distinct yellowish red mottles; friable

Laboratory data

Depth cm	Sand %	Silt %	Clay %	OM %	N %	pH	$CaCO_3$ %
0–10	8.5	71.5	20.0	0.87	0.06	7.0	0.0
10–15	4.3	71.3	24.4	0.38	0.03	7.7	0.75
15–43	9.5	70.2	20.3	0.32	0.03	7.8	1.25
43–69	9.5	66.1	24.4			7.8	1.25

Hatiya series, slightly developed phase: young soil on the Young Meghna Estuarine Floodplain

Noakhali District

Aus—transplanted aman—rabi crops/fallow

Horizon	Depth cm	Description
Ap	0–13	Grey silty clay loam with brownish yellow and yellowish red mottles; massive; firm
B	13–25	Olive-grey silty clay loam with olive and yellowish brown mottles; prismatic and angular blocky structure with broken thin grey coating on vertical faces; firm
C1	25–43	Olive silty clay loam with faint grey mottles; finely stratified; firm
C2	43–81	Olive-grey silt loam with light brown and brown mottles; finely stratified; friable

Laboratory data

Depth cm	Sand %	Silt %	Clay %	OM %	N %	pH	$CaCO_3$ %	Salts ppm
0–13	6.3	65.6	28.1	1.34	0.07	6.5	2.0	1395
13–25	3.5	64.4	32.1	0.68	0.09	8.0	2.7	384
25–43	4.3	65.6	30/1	0.48	0.03	8.0		328
43–81	6.7	76.5	16.8			8.0		357

Note Soils of Hatiya series vary in depth of soil development, but all have a topsoil that has been greatly altered (e.g. in loss of lime and in pH) from that in the original sediment (described in Meghna Mud)

Meghna estuary Mud
Barisal District
Transplanted aman-fallow

Horizon	Depth cm	Description
Ap	0–15	Greenish grey silty clay loam with dark yellowish brown mottles; massive; sticky, plastic wet
C1	15–56	Dark greenish grey silty clay loam stained dark yellowish brown along root channels; massive; sticky, plastic wet
C2	56–86	Dark greenish grey silt loam; massive; sticky, plastic wet

Laboratory data

Depth cm	Sand %	Silt %	Clay %	OM %	N %	pH	$CaCO_3$ %	Salts ppm
0–15	6.4	63.3	39.3	1.16	0.07	7.4	3.0	1100
15–56	6.0	63.5	30.5	1.66	0.07	7.4	2.5	1017
56–86	6.0	71.7	22.3			7.6	4.5	537

Note Mud was not given a soil series name because of its lack of profile development and its exposure to further change by new sedimentation

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Chapter 11
Evaluating Future Threats of Climate Change on Riverine and Coastal Chars

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Abstract Climate-induced hazard is a global problem, which may disproportionately affect those living in riverine and coastal chars in the Ganges–Brahmaputra–Meghna (GBM) delta of Bangladesh, where people's lives and livelihoods are largely dependent on nearby water bodies. By way of a two-dimensional hydrodynamic simulation, effect of climate change has been assessed for riverine and coastal chars in terms of flood disasters. Based on a medium–high carbon emission scenario A1B, which corresponds to the rise of temperature by 2.7° (mid-century) and by 4.85° (end-century) from the present day, with the associated sea-level rise, a total of 14 scenarios has been generated and investigated in fluvial, fluvio-tidal, and storm surge flooding conditions. This study indicates that despite having morphological characteristics similar to the ones in the general area, chars are likely to face different hazard conditions resulting from climatic variables. Significant changes in flood hazards are visualized within the end-century time horizon for both riverine and coastal chars. Coastal polders are likely to play a strategic role in reducing the impacts of climate change-induced hazards.

Keywords Climate change risks · Riverine and coastal chars · Bangladesh

Introduction

The rivers and coast of the Ganges–Brahmaputra–Meghna (GBM) delta are subjected to high temperatures, heavy rainfall, excessive humidity, and distinct seasonal variation due to the tropical monsoon climate that prevails in the area. The seasonal reversal of atmospheric circulation in the winter and summer months is a significant component of climate in the region (Caesar et al. 2015a). The chars, which are an integral part of this delta's dynamic riverine and coastal system, are potentially

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threatened by future climate change and sea-level rise, through extensive monsoon flooding and enhanced cyclone activity (Whitehead et al. 2015b). Though there are ambiguities in climate model predictions on the Asian summer monsoon circulation, most studies project increased temperatures over this region by the end of this century, with a range of uncertainty associated with the greenhouse gas emissions scenario (Allen et al. 2014; Caesar et al. 2015a; Islam et al. 2008). Increased temperature leads to amplification of the region's precipitation, which potentially governs altered flow-sediment regime and changed sea-level for the deltaic river and coast (Masum et al. 2010). The rivers and the coastal distributaries have to cope with these alterations and, during this process, the chars there are likely to experience higher magnitude of climate induced disaster in the way of floods. This chapter focuses on quantifying such disasters in riverine and coastal chars.

In a broad sense, deltaic part of this region experiences three types of flood every year—(i) fluvial flood, (ii) fluvio-tidal flood, and (iii) storm surge flood. The ascendancy of a specific flood depends on the geomorphological characteristics of the floodplain (Brammer et al. 1990). The fluvial flood occurs during the monsoon (June–October), when flow volume in the major rivers (the Ganges, the Brahmaputra, and the Meghna) exceeds their carrying capacity. This heavy fluvial flow interacts with tide in the coastal region, resulting in extensive fluvio-tidal flooding. Storm surge flooding is caused by tropical cyclones formed in the Bay of Bengal and usually occurs during pre and post-monsoon periods, i.e., April, May, and November (Haque et al. 2020). Frequency and intensity of precipitation as well as cyclones are expected to increase due to climate change, which would increase the risk of flooding in future (Alam et al. 2016).

Past studies report that due to increase in global warming by 4 °C from the present day, the major rivers of GBM are subjected to experience an increased (up to 80%) fluvial flow (Immerzeel et al. 2010; Mohammed et al. 2018). The Northern Indian Ocean, including the Bay of Bengal, is likely to experience a relatively higher rate of sea-level rise (SLR) compared to other oceans, which will cause severe fluvio-tidal and storm surge-related flooding in the coastal region (Han et al. 2010; Mohammed et al. 2018). Most of the previous climatic model-related studies are 'region'- or 'basin'-specific, where the attention on river/coastal chars is often ignored due to difficulties associated with downscaling (Alam et al. 2016; Darby et al. 2015; Immerzeel et al. 2010; Mohammed et al. 2018). But flooding being a location-specific phenomenon, its pattern may vary within the same system in the dispersed chars. This chapter attempts to quantify the flooding pattern in changing climate over riverine and coastal chars in different locations that have nearly similar morphological characteristics.

Two climatic scenarios are considered here—mid-century and end-century, when the temperature increases by 2.7 °C and 4.85 °C, respectively, from present day (Darby et al. 2015; Whitehead et al. 2015a). The associated SLR would be 0.61 m and 1.48 m, respectively. Two varieties of chars, riverine and coastal, are selected corresponding to three types of flooding—fluvial, fluvio-tidal, and storm surge flooding. For the coastal chars, impacts of interventions (coastal polder) are also tested to a degree. Cyclone Sidr which made landfall at the east of the Sundarbans on 15

Table 11.1 Climatic conditions and criteria considered

	Flood type	Condition	Criteria	
Riverine chars	Fluvial	Base condition	Average flood Year 2000	
		Present-day extreme condition	Extreme flood Year 1998	
		Mid-century	Temperature: 2.7 °C SLR: 0.61 m	
		End-century	Temperature: 4.85 °C SLR: 1.48 m	
Coastal chars	Fluvio-tidal	Base condition	Average flood Year 2000	
		Mid-century	Maintained polder	Temperature: 2.7 °C SLR: 0.61 m
			Deteriorated polder	
		End-century	Maintained polder	Temperature: 4.85 °C SLR: 1.48 m
			Deteriorated polder	
	Storm surge	Base condition	SIDR like cyclone	
		Mid-century	Maintained polder	SIDR with Temperature: 2.7 °C SLR : 0.61 m
			Deteriorated polder	
		End-century	Maintained polder	SIDR with Temperature re: 4.85 °C SLR: 1.48 m
			Deteriorated polder	

Source Authors

Nov 2007 is considered for storm surge flooding in changing climate. Table 11.1 illustrates details of the scenarios considered in this chapter.

Study Chars

As stated earlier, to assess the impact of climate change on chars, two fundamental systems of GBM are considered—the riverine and the coastal char systems. Chars in Brahmaputra–Jamuna are selected as the riverine chars. The planform of Brahmaputra–Jamuna for 2019 was considered to identify the chars as shown in Fig. 11.1. It consists of around 819 chars. The persistence or age-range of these chars varies from 1 to 30 years (BWDB 2019). Most of the chars are mid-channel island chars (with a few bank-attached chars). According to the process of development, previous

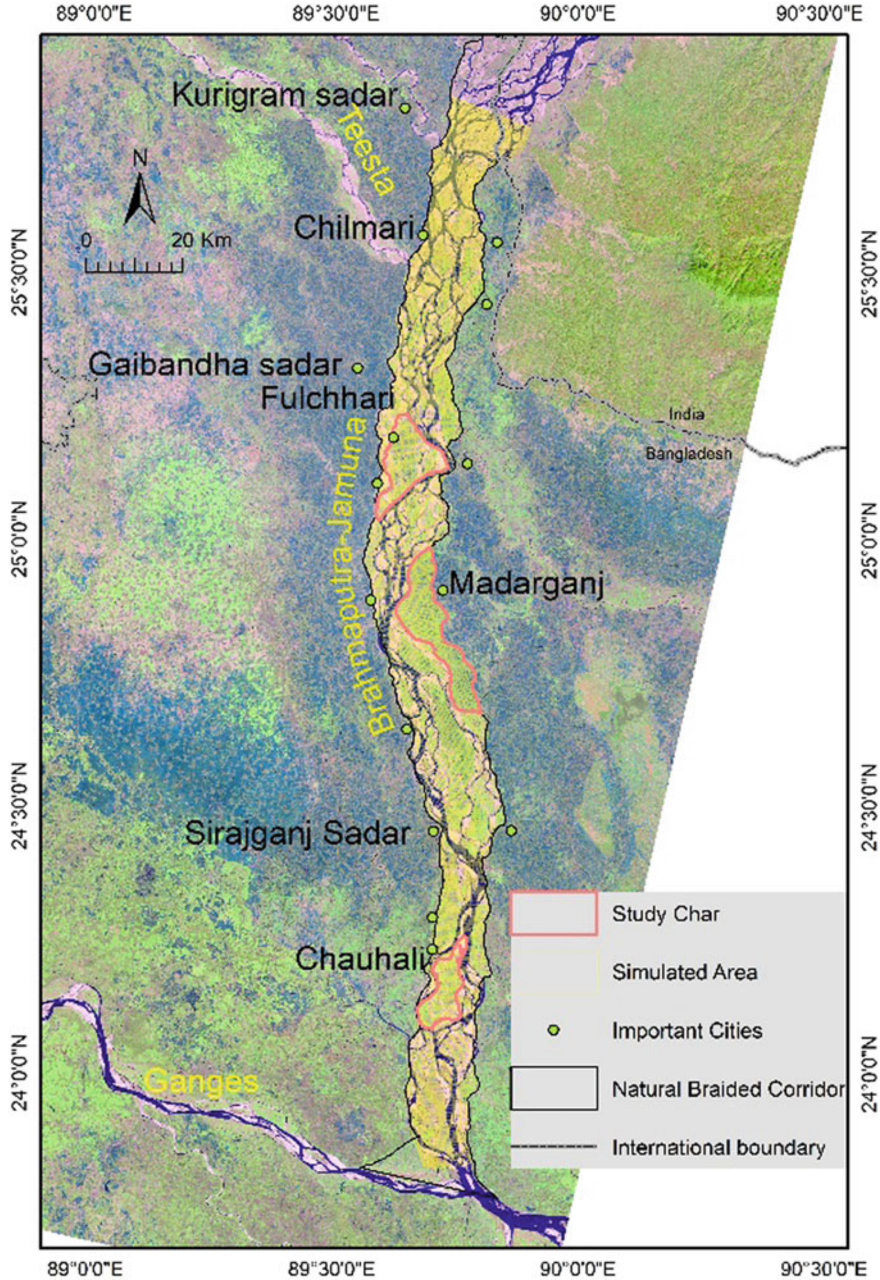

Fig. 11.1 Study area of riverine chars (*Source* Authors)

Table 11.2 Morphological aspects of selected riverine chars

Char type	Forcing type	Braided index (BI) zone	Aspect ratio	Amplitude (m)
Upstream mid-channel char (UMC)	Free bar	3.6~5.2	1.67	13.00
Bank-attached char (BAC)	Forced bar	3.6~4.7	3.32	12.06
Downstream mid-channel char (DMC)	Free bar	3.4~4.9	2.28	12.06

Source Authors

researchers divided the mid-channel chars of the Brahmaputra–Jamuna into two categories—unit mid-channel chars and compound mid-channel chars (Schuurman et al. 2013; Shampa et al. 2017; Shampa (2019)). The persistence of the unit mid-channel char is very low, between 2–3 years; with time these chars merge with other chars forming compound mid-channel chars, or disappear. The compound mid-channel chars usually persist for several years and human settlement there begins within ten years of their appearance (Sarker et al. 2003). From these chars, three were selected, with age greater than 20 years and having human settlement for more than 10 years. The upstream mid-channel chars or free bar (UMC), near Fulchhari, comprise an area of 136 km^2, the bank-attached chars or forced bar (BAC) at Mandarganj total an area of 178 km^2 and the downstream mid-channel chars (DMC) at Chouhali add up to an area of 89 km^2.

Three riverine chars are selected for the study based on characteristics of river morphology (the selected chars have different braided index range) and char/bar mode of formation. Morphological aspects of the selected riverine chars are shown in Table 11.2. Time-series change of the natural braided corridor of the river indicates that the braided belt has a (meandering) tendency to shift westward, especially in the middle reach of the river (Sarker et al. 2014). Resulting from this, a large bank-attached char (point bar) is observed in that region, which may get enlarged in course of time. In the relatively straight reach, possibilities of generating mid-channel chars (free bars) are high. Therefore, the selected chars basically cover the probable planimetric characteristics of future chars.

Though the chars have similar amplitudes (varying between 12 and 13), these exist in different braided index (BI) zone of the river, as mentioned earlier. As the selected chars are compound in nature, the land persistence (age of land at different locations of a compound char) may play a key role during the river flood. Figure 11.2 shows the land persistence of the selected chars. Among the selected chars UMC has a higher percentage (29%) of young lands (ranges between 1 and 5 years). The BAC has relatively higher percentage (41%) of old lands (age range being 26–30 years).

The coastal estuaries of GBM are tide-dominated, producing numerous chars in this holocene. Morphologically, the process of formation is quite similar to riverine chars, and with passage of time, some of these chars become larger, offering favorable

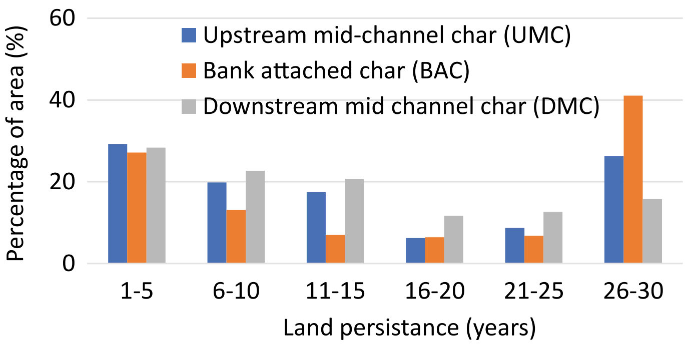

Fig. 11.2 Land persistence or age of lands in selected compound riverine chars. *Source* Authors

condition for human settlement. Generally, among the coastal chars, the larger (i.e., area more than 100 km^2) and older (i.e., age more than 50 years) are called islands (i.e., Hatiya, Sandwip) but from the hydromorphic point of view considered in this study, they are the same (with the exception of surface roughness and landuse pattern).

In the coastal region, five chars are selected in Sibsa, Tetulia, and Lower Meghna estuarine system as shown in Fig. 11.3. Morphological characteristics of the selected coastal chars are presented in Table 11.3. Dublar Char, Hatiya, and Sandwip experience similar tidal range (2.30 m), but chars in the active estuarine plane experience relatively higher tidal (>2.50 m) range (Brammer 2014). For eastern chars/islands (Hatiya and Sandwip), amplitudes are nearly 1.5 times higher than the others. Since the currently existing polders may play a significant role in future flooding, the study

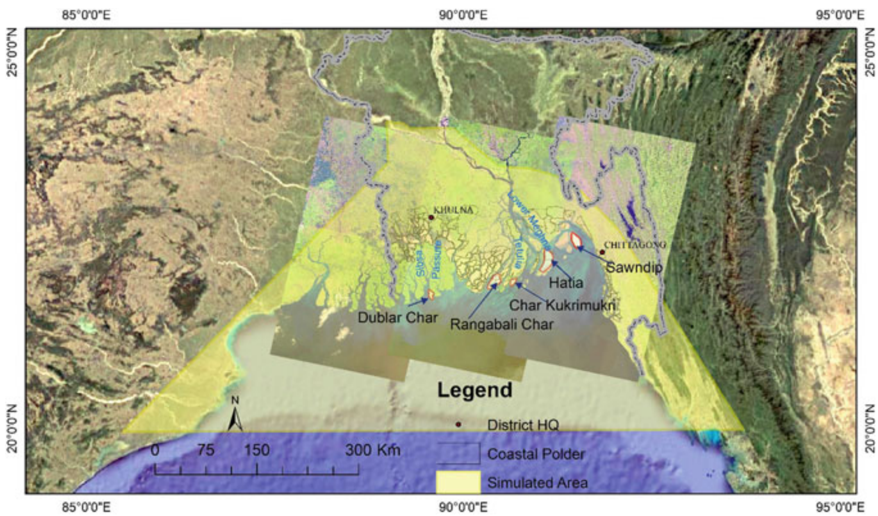

Fig. 11.3 Study area of coastal chars. *Source* Authors

Table 11.3 Morphological aspects of selected coastal chars

Char type	Forcing type	Aspect ratio	Tidal range (m)	Amplitude	Area (km^2)
Dublar char	Free	2.03	2.30	11.37	66
Rangabali char	Free	2.36	2.58	17.58	240
Char Kukrimukri	Free	2.02	2.50	9.67	59
Hatiya	Free	2.70	2.30	15.4	327
Sandwip	Free	2.22	2.30	22.42	201

Source Authors

chars are selected in such a way that these can represent both poldered and non-poldered chars. Among the selected chars, Dublar char and char Kukrimukri are not protected by coastal polders, while rest of the chars have been so protected for several years.

Methodology

Climate change threatens increase in the severity of damaging flooding events all across the globe (Uhe et al. 2019). More rainfall is expected due to warmer atmosphere resulting from climate change. Climate change may affect the mean annual rainfall and also cause extreme events. Increased rainfall drained by the rivers is likely to result in such discharges that may adversely impact the chars within the system. Impact of climate change on chars in this context has been assessed through a 2D hydrodynamic numerical simulation, considering several climatic scenarios as mentioned in Table 11.1. Physical hazard maps have been developed on the basis of model results on inundation depth, flood velocity, and flood duration. Details of the methodology used are presented in the following.

Schematization of the Numerical Model

Two-dimensional hydrodynamic numerical simulation was performed to assess climatic impact on chars using a well-known open-source numerical model Delft 3D (flow version 4.00.01.000000; model details can be found in Lesser et al. 2004). The 2D model solves the two-dimensional depth-averaged nonlinear shallow water equations derived from Navier–Stokes equations for incompressible free surface flow (shallow water equations) with the consideration of Boussinesq approximations. Two model setups were constructed separately for riverine and coastal chars.

For riverine chars, the calibrated and validated model described in Shampa et al. was used. The braided bathymetry was developed using the planform of 2019, cross sections from BWDB and topography from SRTM data as shown in Fig. 11.4. For

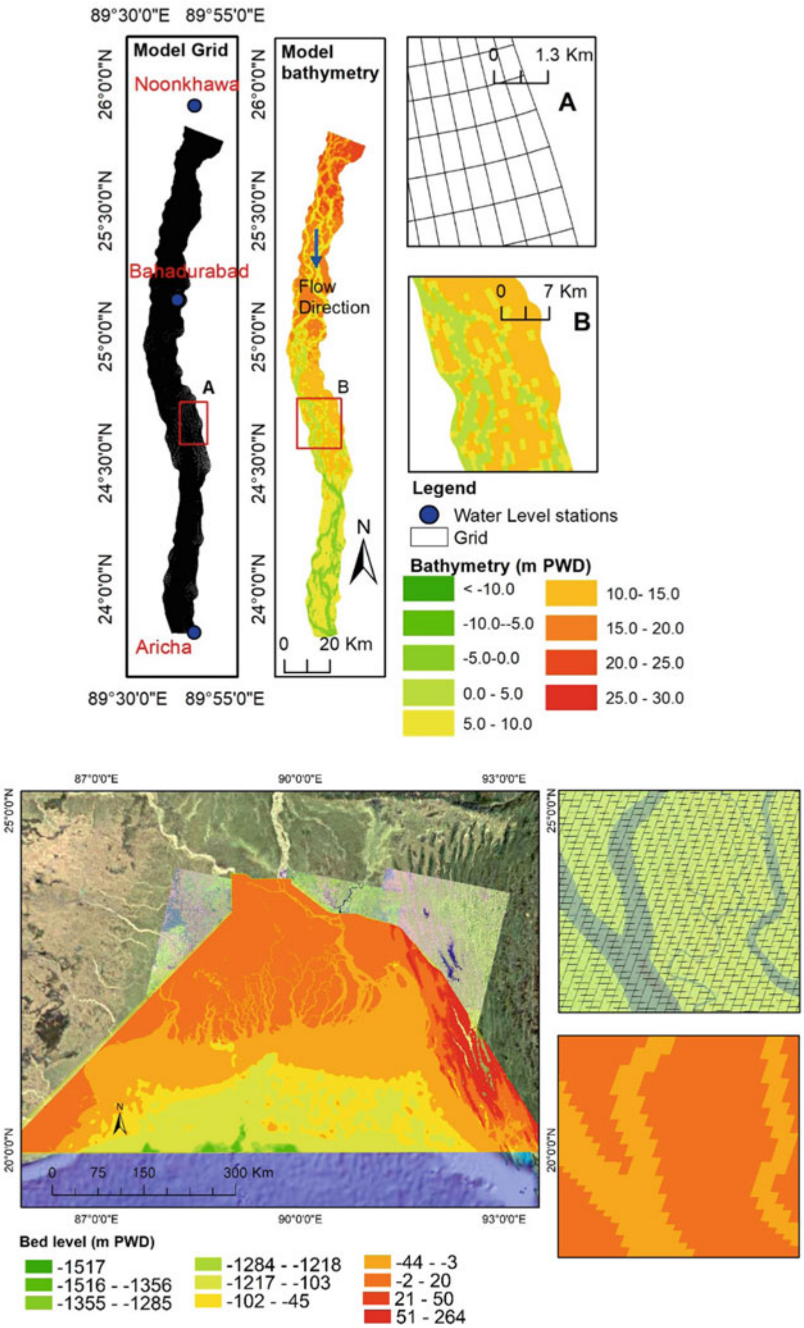

Fig. 11.4 Model grid and bathymetry for riverine (upper) and coastal model (lower). *Source* Authors

the numerical model, a 225 km long curvilinear grid was constructed with an average width of 13 km, starting from around 10 km downstream of the Noonkhawa water-level measuring station and ending near Aricha water-level measuring station. The reach was discretized by 1117 × 73 grid cells. This grid resolution was chosen to cover every char by at least two grid cells (grid cell size 201 × 178 m^2) because the char sizes range from 549 × 205 m^2 to 28,635 × 10,475 m^2 within the reach of Brahmaputra–Jamuna.

The effect of climate change on coastal chars was assessed using a calibrated and validated coastal model for the GBM delta as described in Haque et al. (2016). For the coastal model, topography was prepared from the digital elevation model (DEM) available in the database of Water Resources Planning Organization (WARPO). The DEM in its current form has a 50 m × 50 m resolution. A total of 294 measured cross sections from different projects of IWFM, BUET, and available recent river cross sections from BWDB were used to generate the river bathymetry. Open-access data from the General Bathymetric Chart of the Oceans (GEBCO) was used for sea bathymetry. Maps available at WARPO database were used for coastal polcders. Design polder heights were specified from BWDB. Both simulations ignored morphological changes (bankline shifting, bed-level changes, and floodplain sedimentation) during the flood. Flooding due to polder overtopping was considered, though not the polder breaching phenomenon. Land cover and land use were considered as surface resistance parameters.

The models were simulated using present-day conditions and climatic projected scenarios for the mid- and end-century. BWDB (2015) classified flood according to level of flood extent, which were used in defining base and present-day extreme conditions. Here, in the case of riverine flood, the base condition represents the flooding condition of the year 2000 and the present-day extreme represents the flooding condition of the year 1998. For the climatic scenarios, the upstream flows are computed with the INCA and HydroTrend models that use the widely known Special Report on Emissions Scenarios (SRES) A1B climate scenario (Darby et al. 2015; Whitehead et al. 2015b). A1B, a medium–high carbon emission scenario, was developed for the IPCC Third Assessment Report that still underpins much recent research into climate impacts.

The discharge boundary conditions were defined over Brahmaputra–Jamuna, Ganges, and Meghna rivers, as found in Fig. 11.5. For the coastal model, southern boundary of the GCOMS simulation of Bay of Bengal is provided as the tidal water levels (Kay et al. 2015). An example of sea boundary conditions is shown in Fig. 11.6.

Assessment of Flood Hazard

The numerical model results simulate inundation depth, velocity, and duration of flood hazard. The char people are used to living with flood. A survey for the present study was conducted during January 2020 in the chars of Brahmaputra–Jamuna to assess their perception of flood hazards. From the local people's perception, literature

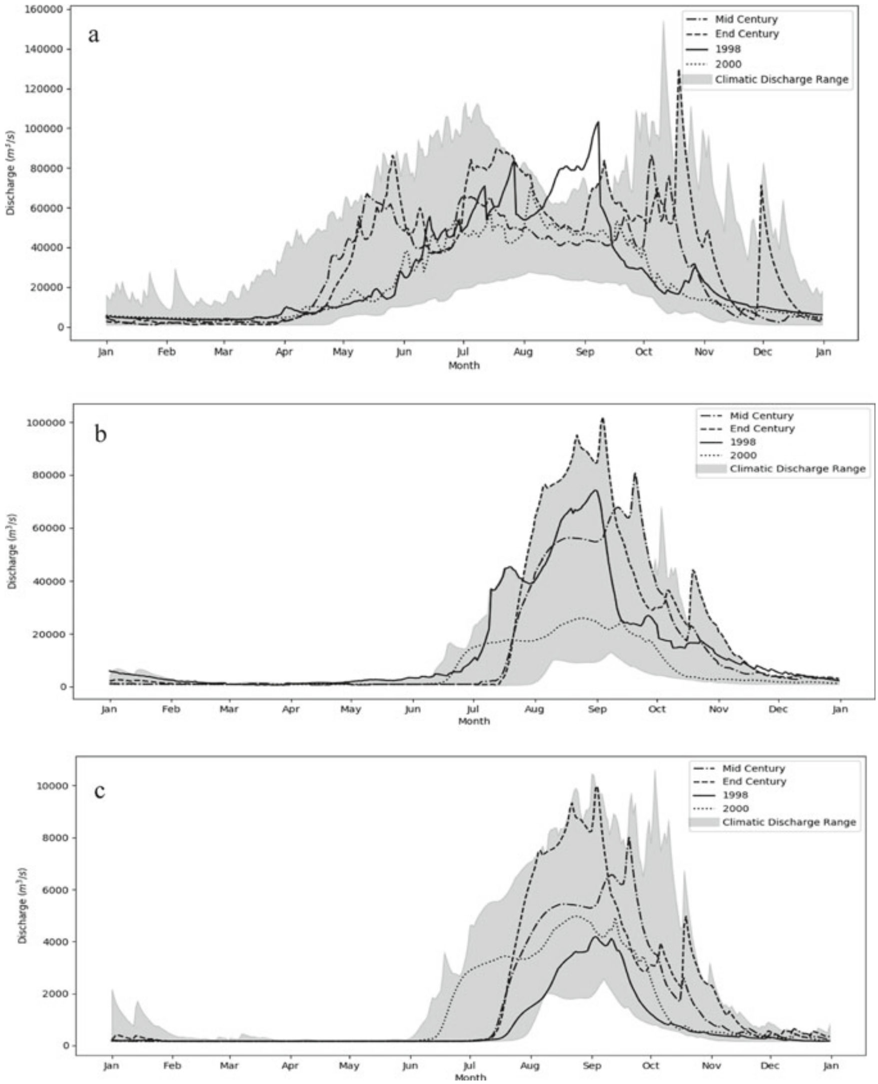

Fig. 11.5 Discharge boundary conditions of the simulation: **a** Brahmaputra–Jamuna. **b** Ganges. **c** Upper Meghna. *Source* Authors

review and model results several flood hazard indices are assigned ranging from 0 to 4 as depicted in Table 11.4. Hazard ranking 0 indicates very low hazard corresponding to the inundation depth range of 0–1 m, overland flood velocity of 0 to 0.4 m/s with average flood duration, which is 75 days for riverine flood. Accordingly, rank 3 indicates a very high hazard with severe damage on life and livelihood corresponding to flooding depth greater than 3 m, with high velocity (>1.23 m/s) and 60% longer duration than average.

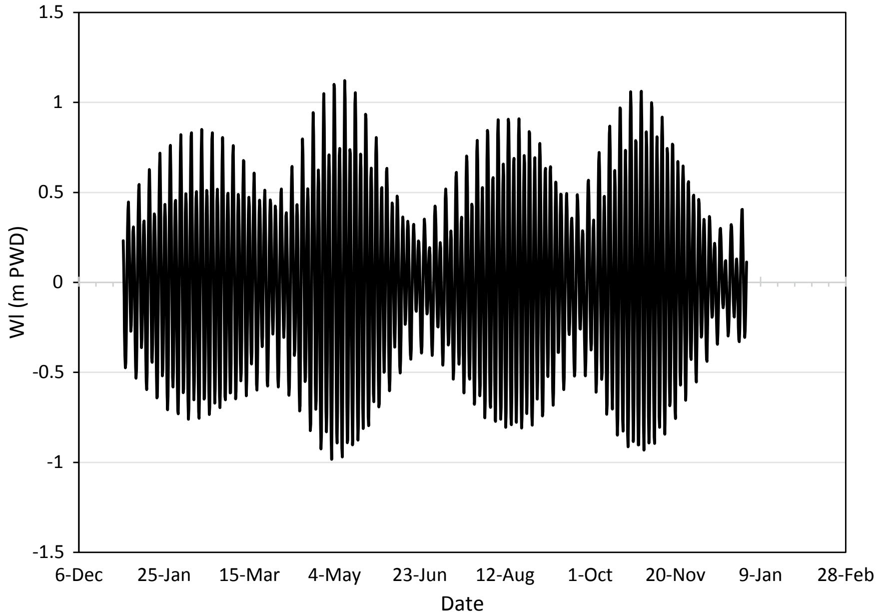

Fig. 11.6 Example of sea boundary condition (base condition). *Source* Authors

Table 11.4 Description of the hazard scale

Flood depth (m)	Flood velocity (m/s)	Flood duration (days)	Hazard ranking	Hazard zone	Definition of the hazard zone
0–1	0–0.4	Average flood duration	0	Low	Casualties and property damage is expected to be very low
1–2	0.4–0.8	20%	1	Medium	Casualties and property damage is expected to be relatively higher
2–3	0.8–1.23	40%	2	High	Damage to property is quite extensive and the probability of casualties is high
>3	>1.23	60%	3	Very high	At all levels, severe damages are expected

Source Authors

Flooding Characteristics of Chars in a Changing Climate

Riverine Chars

Under average flooding conditions (used as base condition in this study), flood depth varies between 0.50 m and 1.2 m within the riverine study chars. Average duration of flooding is nearly three months. The upstream mid-channel chars (UMC) seem to be flooded over 40% of its area, which is 1.5 times greater than the other chars. It reflects the presence of younger land in UMC. Average flood velocity is observed to be 0.75 m/s. Characteristics of flooding in the base condition are presented in Table 11.5.

In the present-day extreme scenario (selected as 1998 flood in this study), the average inundation depth found in the selected chars is 2.06 m, which is almost twice than the base condition. UMC exhibits 2.4 m of inundation depth which is 3 times lower (0.72 m) than the bank-attached chars (BAC). For the downstream mid-channel chars (DMC), the inundation depth is 3.01 m. The average inundation depths in mid- and end-century scenarios are 1.7 m and 2.5 m, respectively (see Fig. 11.7).

In mid-century and end-century scenarios, relatively higher inundation depth is observed in DMC. This phenomenon reflects the effects of downstream control in char flooding. In 1998 flood, the peak synchronization of Ganges, Brahmaputra–Jamuna, and Upper Meghna aggravated the flooding condition Islam et al. (2010). In changing climatic scenarios, due to the change in base level, the flood depth is likely to increase in downstream chars. The overall flood velocity in the selected chars is 0.72 m/s. Figure 11.8 shows distribution of flood velocity in present-day extreme scenario. This figure indicates that in bank-attached chars the flooding is basically over-char flow. But in the mid-channel chars, the bifurcated channel also spills and causes flooding. In mid-century and end-century scenarios, the average flood velocities are 0.80 m/s and 0.94 m/s, respectively.

Results on inundated area are listed in Table 11.6. Data in this table indicate that in all climatic conditions flooding area will increase from base condition. In UMC,

Table 11.5 Flooding characteristics of riverine chars in the base condition

Char types	Average flood depth (m)	Average flood velocity (m/s)	Percentage of flooded area (%)
Upstream mid-channel char (UMC)	1.2	0.79	40.78
Bank-attached char (BAC)	0.5	0.63	15.60
Downstream mid-channel char (DMC)	1.0	0.83	26.20

Source Authors

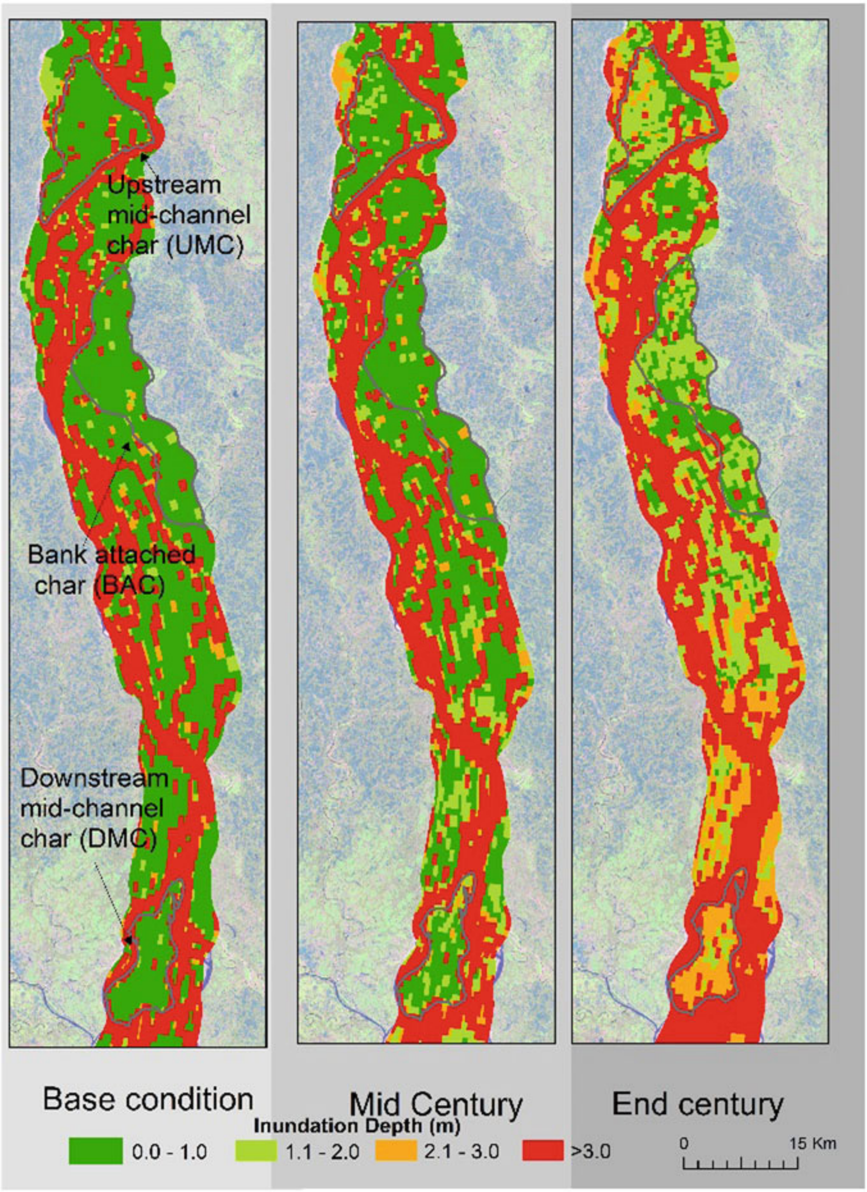

Fig. 11.7 Flood inundation at peak flood time under different scenarios. *Source* Authors

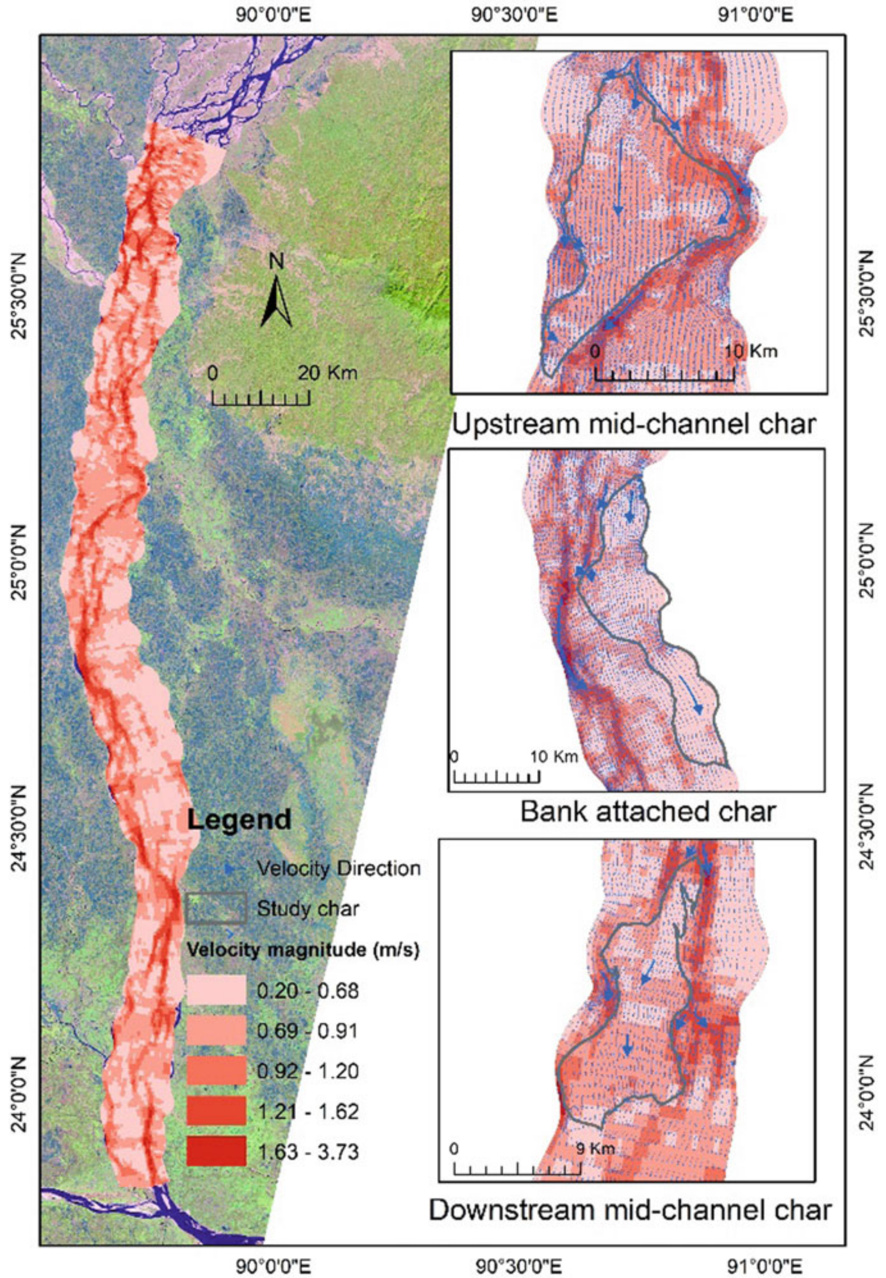

Fig. 11.8 Distribution of flood velocity in present-day extreme scenario. *Source* Authors

Table 11.6 Inundation characteristics of riverine chars in different scenarios

Scenario	Date of flood initiation	Date of flood Peak	Date of flood recession	Inundated area (km^2)			Excess/deficit to base year (%)		
				Upstream mid-channel char (UMC)	Bank-attached char (BAC)	Downstream mid- channel char (DMC)	Upstream mid-channel char (UMC)	Bank-attached char (BAC)	Downstream mid- channel char (DMC)
Base year	First week of July	Second week of August	Fourth week of October	52.51	29.13	21.06	–	–	–
Present-day extreme	Second week of July	Second week of Sept	Fourth week of October	99.6	88.6	60	90	204	185
Mid-century	Last week of May	First week of Oct	Last week of Nov	104	118.9	80.4	98	308	282
End-century	Last week of May	Mid-July and Mid-Oct	Last week of Nov	127.40	179.43	80.4	143	516	282

Source Authors

the extent of flooding is likely to increase twice in mid-century, whereas DMC may be fully inundated (see Fig. 11.7). End-century flooding extent seems to be severe in all chars. The mid-channel chars are likely to be 100% flooded, while only 3% of total area of BAC will be free from inundation (see Fig. 11.9 and Table 11.6).

Physical flood hazard maps for different climatic scenarios are prepared by using the model results (plotted in Fig. 11.9). This figure indicates that with the progression of time from present-day to end-century, the flood hazard in char increases. Mid-channel chars show very high flood hazard while bank-attached chars show low to no hazard condition. Among the mid-channel chars, the downstream chars are more hazard-prone compared to upstream chars due to extreme base-level condition.

Coastal Chars

Fluvio-tidal flood: Under average flood conditions (base condition: year 2000), flood depth in coastal chars varies from 1.92 m to 3.4 m in the selected coastal chars with maximum flood extent of 60% of total char area in non-poldered chars (char Kukrimukri). In poldered chars, only 22% of char area is flooded where the tidal range is relatively high (Rangabali Char). The flood velocity in coastal chars varies from 0.05 m/s to 0.16 m/s. The characteristics of fluvio-tidal flood in coastal chars in base condition are shown in Table 11.7.

In the changing climatic scenarios, the inundation depth increases nearly 1.5 times in mid-century and 2 times in end-century. Figure 11.10 shows the inundation scenario in different climatic conditions.

This figure (Fig. 11.10) indicates that due to sea-level rise and increased upstream discharges, end-century scenario is likely to be severe for coastal chars. The situation would be more severe in areas where protective coastal polders are poorly maintained, the inundation depth there increasing by about 1.6 times that of areas witin well-maintained polders.

Table 11.8 presents mid-century and end-century distribution of flood velocity in coastal chars. In comparison to base condition, the change in velocity toward mid- and end-century is not significant (average velocity in base condition is 0.11 m/s, during mid-century it is 0.12 m/s and during end-century, 0.14 m/s). In deteriorated polder condition, flood velocity decreases both during mid- and end-century.

Decrease in flood velocity in deteriorated polder condition is due to the increased area getting flooded with the same volume of water. In climatic conditions of mid-century as well as end-century, inundated area increases compared to the base condition. Among the non-poldered chars, Dublar char is likely to experience the maximum inundation during mid- and end-century (168% and 182%, respectively, in excess from the base condition). Compared to the protected chars, the chars of the active estuarine plane show more inundation (260% in excess from the base condition) with deteriorated polder condition. This shows the importance of polder maintenance for the protected chars.

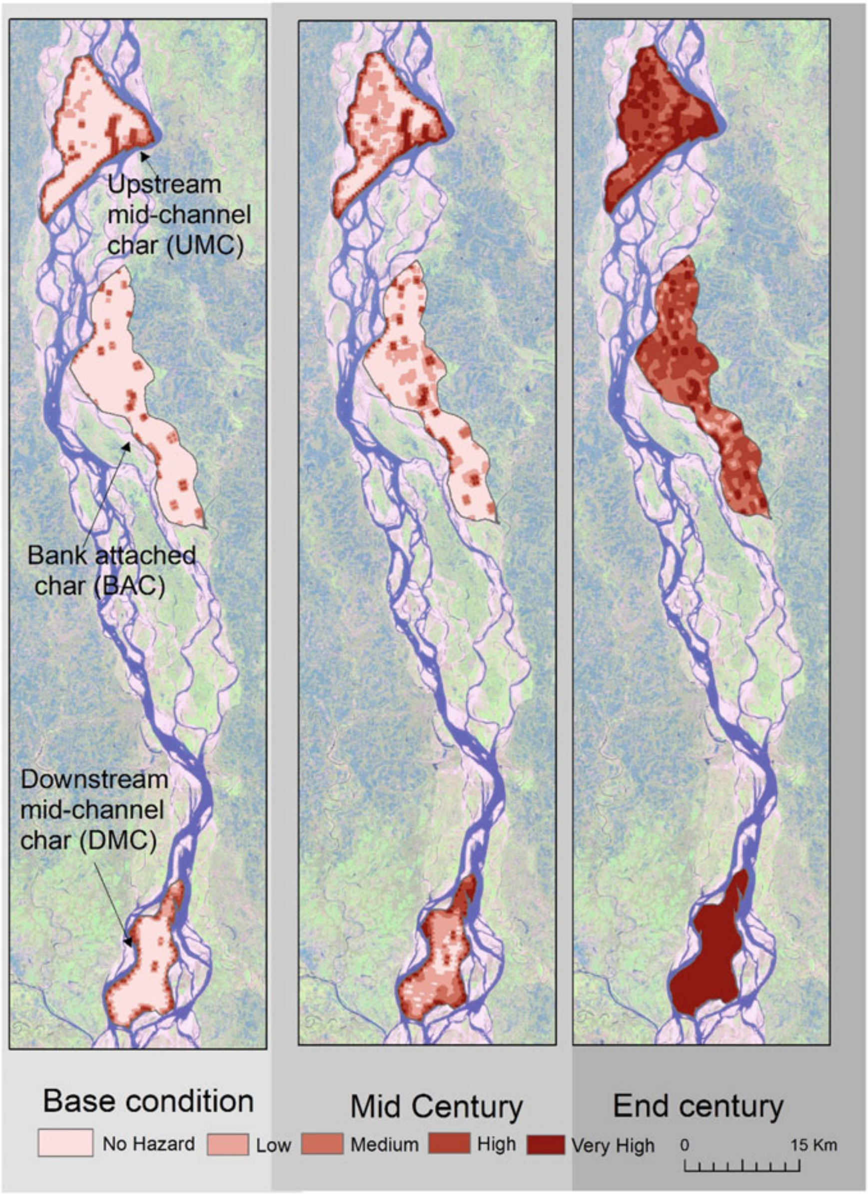

Fig. 11.9 Flood hazard map for selected climatic scenarios. *Source* Authors

Table 11.7 Characteristics of fluvio-tidal flood in coastal chars in base condition

Chars	Average flood depth (m)	Average flood velocity (m/s)	Percentage of flooded area
Dublar char	0.65	0.050	35.44
Rangabali char	0.38	0.160	22.86
Char Kukrimukri	1.41	0.131	60.57
Hatiya	0.16	0.123	12.44
Sandwip	0.47	0.134	16.18

Figure 11.11 presents the hazard map for fluvio-tidal flood of coastal chars, which shows an escalation in hazard during end-century in areas within polders having deteriorated in condition.

Storm Surge Flooding

GBM delta has a long history of tropical cyclones. The tropical cyclones and associated tidal surges frequently damage lives and properties in coastal islands (Alam and Collins 2010). The Bay of Bengal acts as an energetic zone in the Indian Ocean for developing cyclones and around 7% of all these cyclones hit the coast Nihal et al. (2015). Around 70% of the tropical cyclones hit in the months of April–May and October–November. Water-level variation in tidal rivers during storm surge is different from normal tide condition. Figure 11.12 shows an example of water level in a tidal river during normal tide and during storm surge at a similar time span (near Dublar char). This is evident during the dry period (November), so fluvial impact is negligible. Here in excess of tide level, an additional surge level is clearly visible during storm surge. This additional surge level makes inundation during storm surge flooding more severe than fluvio-tidal flooding.

Some recent cyclones such as Sidr (Nov 2007), Ayla (May 2009), and Roanu (May 2018) caused storm surge floods, resulting in significant loss of life and livelihood (Rahman et al. 2019). Storm surge flooding caused by cyclone Sidr, which was a category IV cyclone (Saffir-Simpson hurricane scale, Extremely Severe Cyclonic Storm), resulted in casualties of nearly 3000 people and property damage of around $1675 million (GoB/Government of Bangladesh 2008; Haque and Jahan 2016). The storm started to intensify into a cyclonic storm in the Bay of Bengal at 0300 UTC on November 11, 2007 and initially propagated in the north–westerly direction. With a minimum pressure of 992 hPa and maximum wind speed of about 28 m/s, the storm then moved further to the north-easterly direction and made landfall at the coast of Bangladesh at 1600 UTC on November15, 2007 (Rahman et al. 2019). It is considered to be the most severe cyclone to make landfall in Bangladesh coast since 1991 (Hutton et al. 2018).

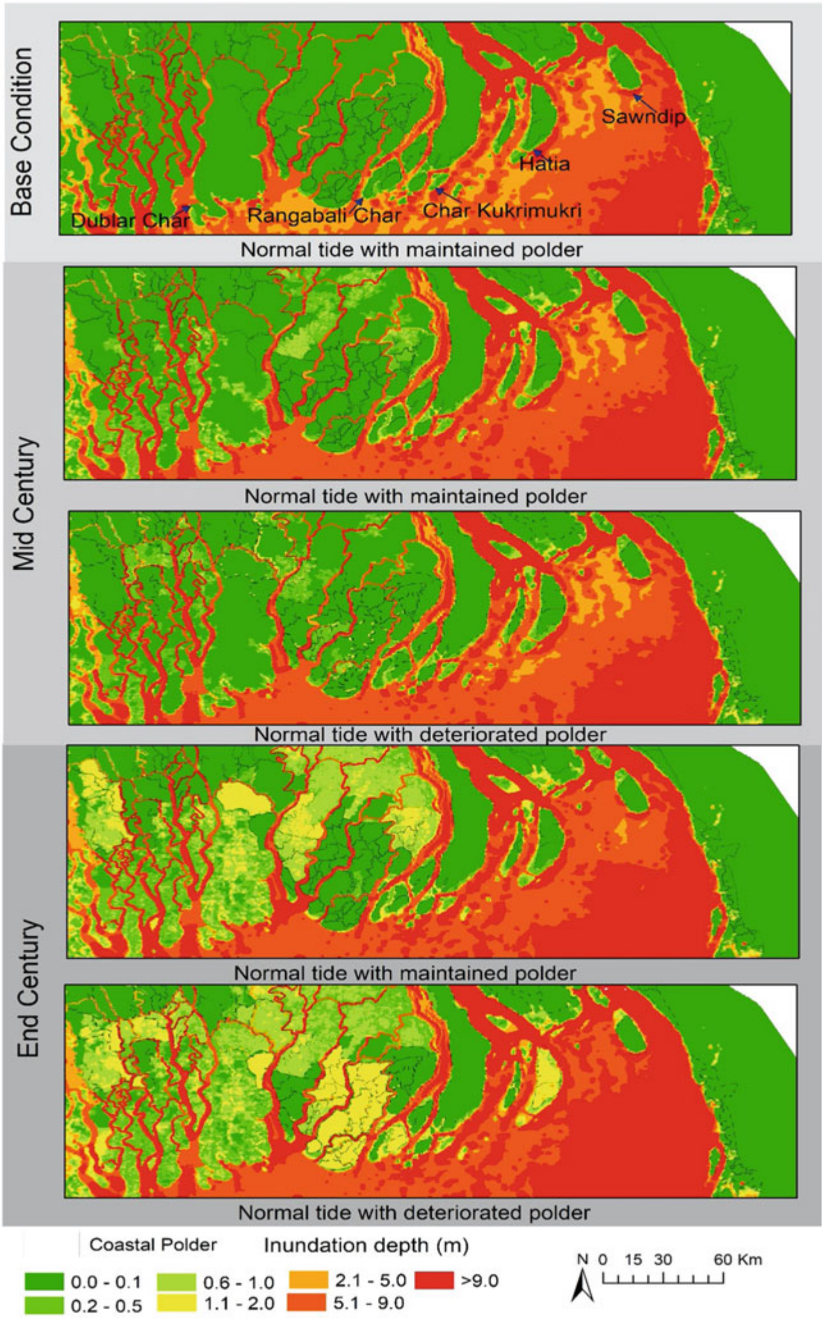

Fig. 11.10 Fluvio-tidal inundation in coastal area. *Source* Authors

Table 11.8 Depth-average flood velocity in coastal chars during fluvio-tidal flood

Chars	Mid-century		End-century	
	Maintained polder	Deteriorated polder	Maintained polder	Deteriorated polder
Dublar char	0.11	0.11	0.17	0.17
Rangabali char	0.14	0.13	0.19	0.11
Char Kukrimukri	0.18	0.15	0.19	0.18
Hatiya	0.07	0.05	0.09	0.02
Sandwip	0.14	0.14	0.15	0.15

Source Authors

The storm surge simulation was done using Delft Dashboard and Delft 3D Flow as discussed in Nihal et al. (2015). Instead of simulating a full group of extreme events, a historical analog approach is adopted here to capture the impact of extremes by simulating a known cyclone, which was cyclone Sidr. Four future scenarios are generated with cyclone Sidr, by way of considering mid-century and end-century time scales, with well-maintained polder and deteriorated polder.

The base condition represents the actual scenario of cyclone Sidr where the flood depth due to storm surge varies from 2.6 m to 3.8 m in the coastal chars described in this chapter. Low-lands of Char Kukrimukri experience the maximum flood depth (>16 m). Overland velocity varies from 0.10 m/s to 0.31 m/s. The real extent of flooding measured as a percentage of the flooded area in different chars is listed in Table 11.9.

Figure 11.13 shows inundation depth of coastal chars due to flooding from Sidr (including the main land coast) for different climatic conditions, starting from the base condition (actual Sidr or Sidr-base) to conditions toward mid-century and end-century.

In Sidr-mid-century scenario, the average inundation depth increases to 3.4 m from base condition. The maximum inundation depth is observed during Sidr-end-century scenario where the surge depth is nearly 17.40 m in the low-land of Char Kukrimukri. The surge depth is the combined effect of tide and surge. The high surge depth at Char Kukrimukri is due to the fact that the cyclone made landfall during high water spring tide and the land is low land. Table 11.10 summarizes the areal extent of flooding, measured as a percentage of total inundated area. If the polders are poorly maintained, a number of polders would be overtopped, causing extended flooding of previously protected areas.

Figure 11.14 shows a flood inundation map and a flood hazard map in the event of Sidr like cyclone in changing climatic conditions over time. These figures show that Char Rangabali and Char Kukrimulri are more hazard-prone than the other chars

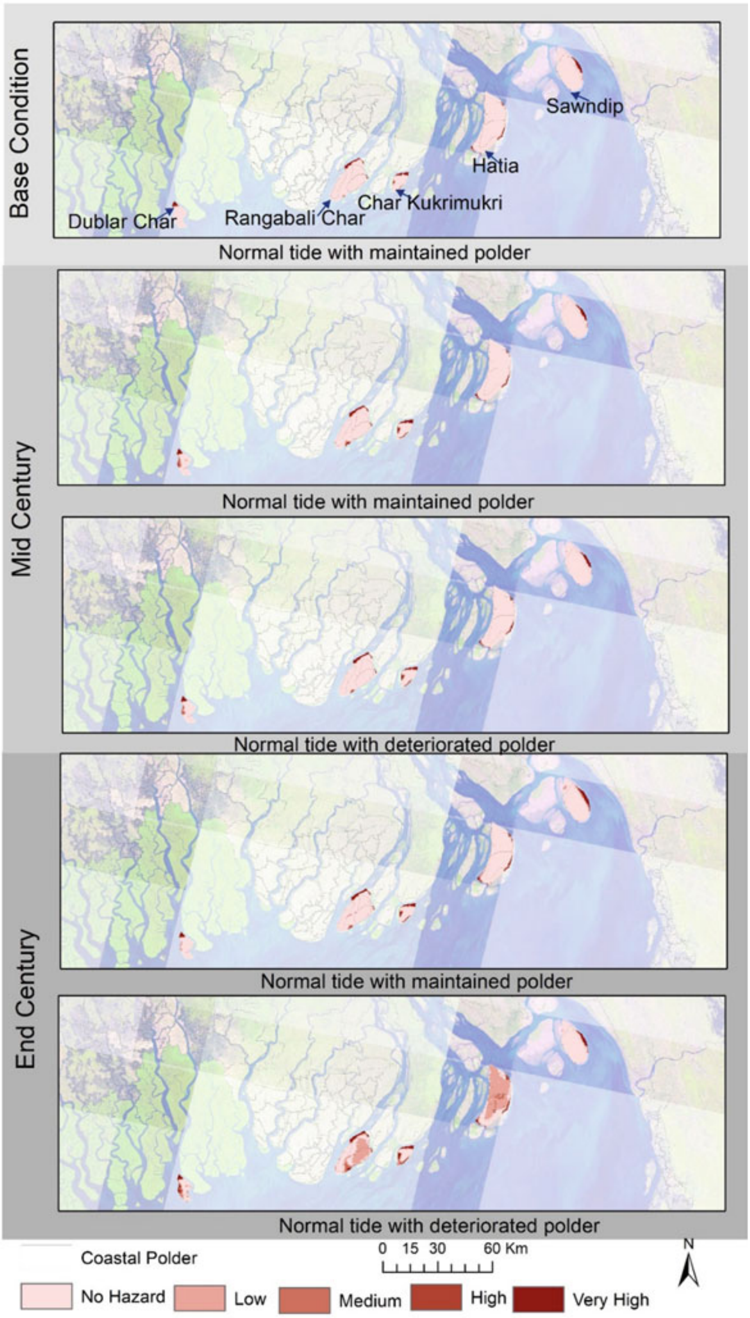

Fig. 11.11 Flood hazard map of coastal chars during fluvio-tidal flooding. *Source* Authors

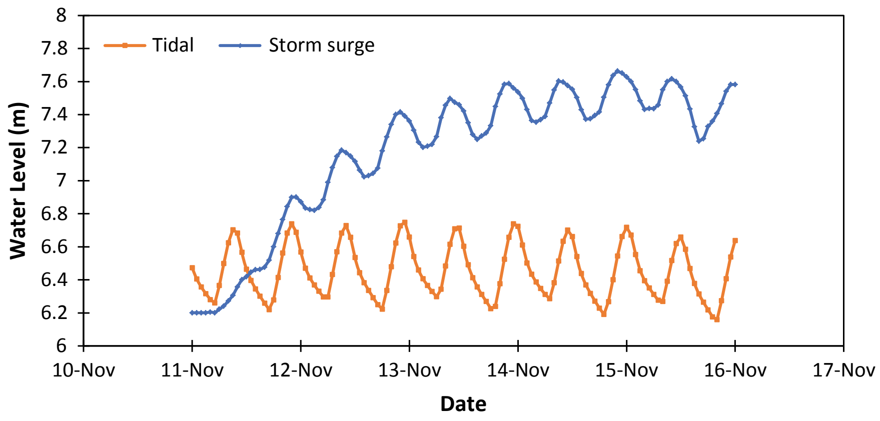

Fig. 11.12 Typical water-level variation during normal tidal and during storm surge in river near Dublar char

Table 11.9 Areal extent of flooding due to cyclone SIDR

Char	Dublar char	Rangabali char	Char Kukrimukri	Hatiya	Sandwip
Percentage of flooded area	28.66	23.13	66.92	13.2	18.03

Source Authors

mainly due to the propagation path and landfall location of cyclone Sidr. The situation would change if a cyclone with different track makes landfall in a different location. Sea-level rise and any deterioration of polder condition would make the situation worse during end-century.

Concluding Remarks

Climate change threatens an increase in the frequency as well as intensity of a number of hazards for the charlands in Bangladesh. In the current chapter, the impacts of climate change on riverine and coastal chars have been assessed through numerical simulation of flood, taking into account changing climatic conditions. Two climatic conditions representing the rise of temperature by 2.7° and 4.85° with the associated sea-level rise (by 0.61 and 1.48 m, respectively) have been investigated, taking into account the effect of man-made interventions (i.e., polder). Based on simulation results, it can be concluded that the chars can be affected disproportionally by climate-induced natural hazards.

In the case of riverine chars (i.e., Brahmaputra–Jamuna), the downstream chars are more hazard-prone though they possess a similar bar-amplitude in mid- and end-century time horizons. Due to changing climate, flood duration becomes longer and

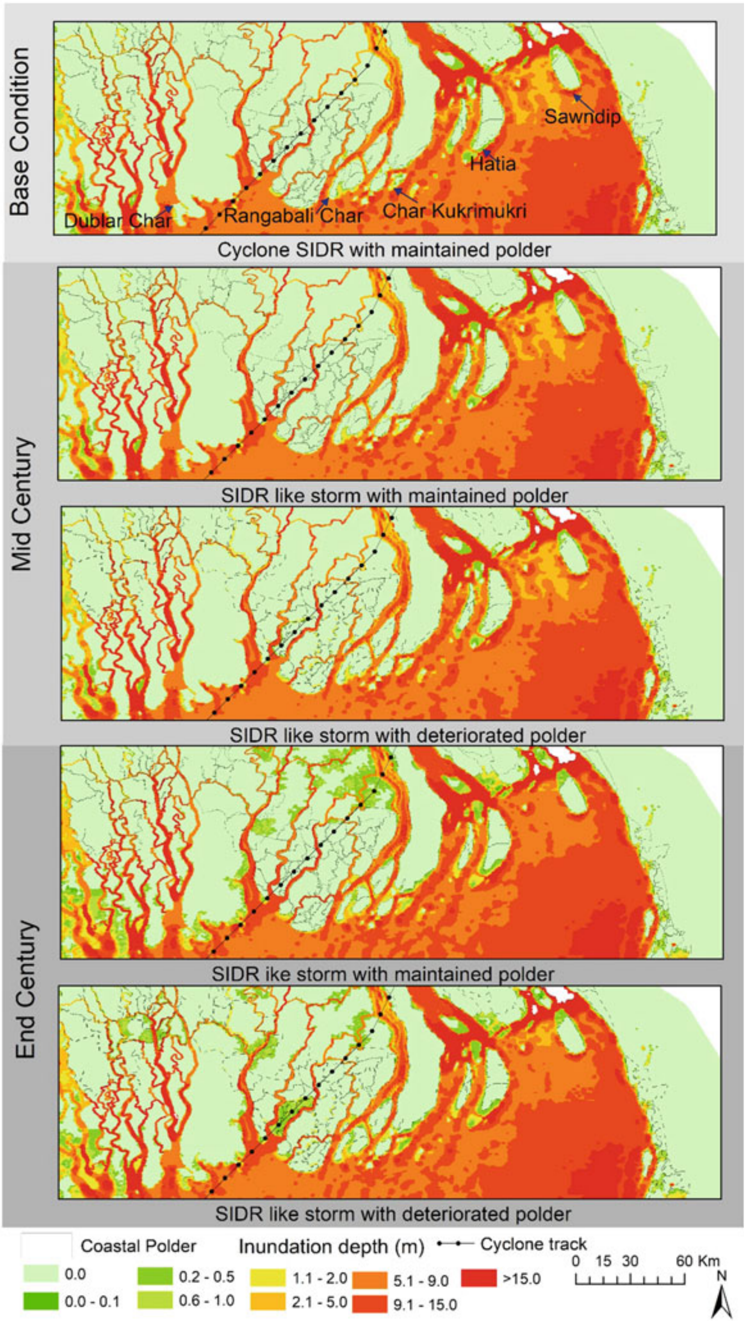

Fig. 11.13 Inundation due to SIDR like cyclone in changing climatic conditions over time. *Source* Authors

Table 11.10 Percentage of inundated areas due to cyclonic conditions

Scenarios		Percentage of inundated areas				
		Dublar char	Rangabali char	Char Kukrimukri	Hatia	Sandwip
Sidr-base		28.66	23.13	66.92	13.2	18.03
Sidr mid-century	Maintained polder	30.09	22.86	59.41	11.72	18.2
	Deteriorated polder	29.78	22.86	59.41	11.99	18.2
Sidr end-century	Maintained polder	78.03	46.06	94.1	24.3	24.1
	Deteriorated polder	65.92	43.59	93.11	24.66	23.68

Source Authors

likely to continue till end of November. In the context of flood hazard, the bank-attached chars are safer than mid-channel island chars. In coastal areas, the chars in the active estuarine plane are more susceptible to climate change. Even in the present day, these chars experience regular tidal inundation. Flood velocity is usually lower in coastal chars compared to riverine chars. Change in velocity during changing flood condition is also negligible. For both fluvio-tidal and storm surge floods, flood extent and hazard magnitude are affected by the presence of polders for the protected coastal chars. Flood hazard in the protected coastal chars would increase at the end of century if the condition of the protective polders is found to deteriorate.

Climate change is likely to increase the flood magnitude and flood extent in riverine and coastal chars toward mid-century as well as end-century. Flood mitigation policy should focus on proper landuse planning for the people living in riverine chars. For the coastal chars, polder is found to be an effective structural adaptation measure to reduce the flood hazard which will ultimately minimize flood risk in future. Flood hazard in coastal chars increases with deterioration in the condition of polders. For policy planning, polder maintenance should be prioritized instead of increasing polder heights. Long-term sediment management policy can accelerate the land building process of both riverine and coastal chars. This will reduce flood hazard of char land people in changing climatic conditions.

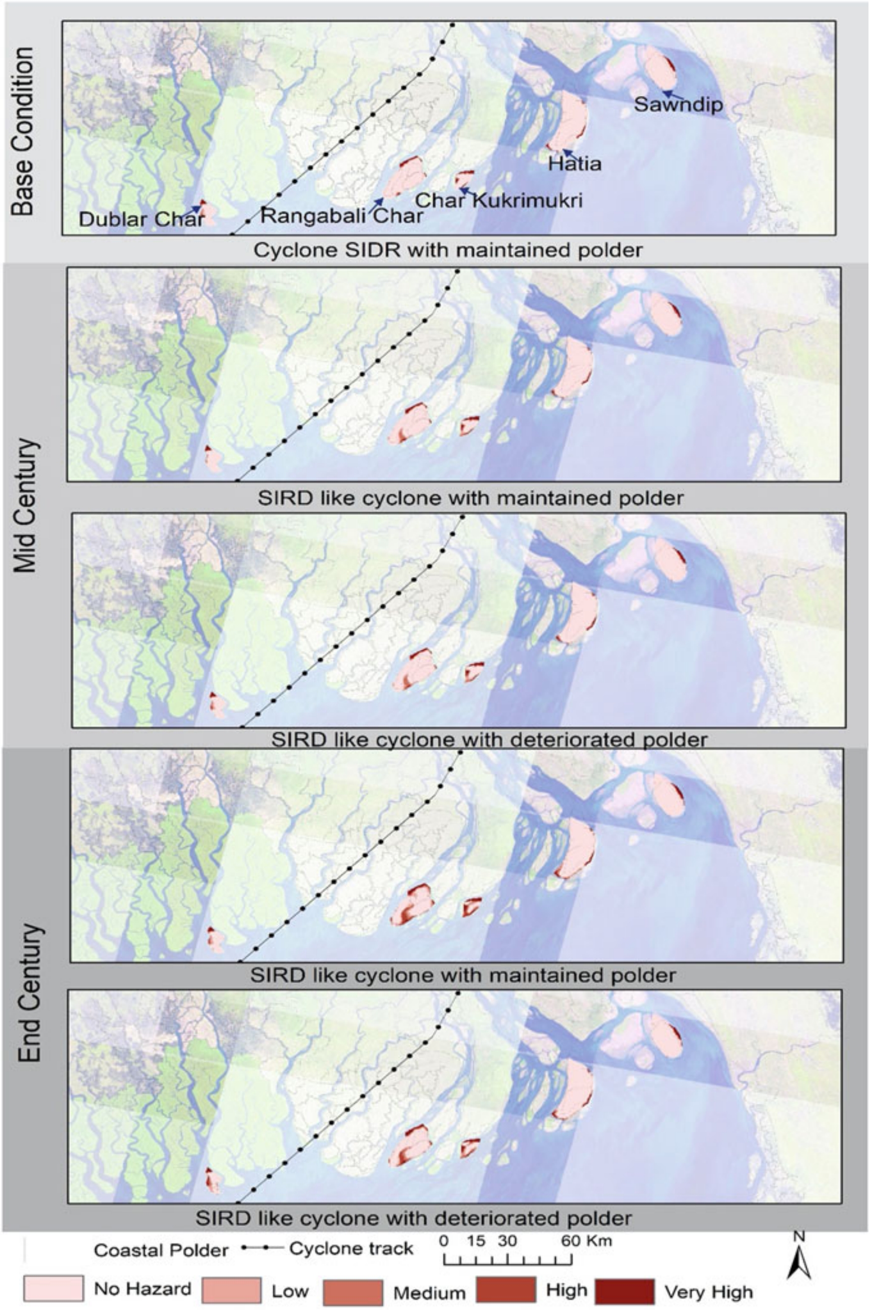

Fig. 11.14 Flood hazard map due to Sidr like a cyclone in changing climate over time. *Source* Authors

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Part IV
Flood and Erosion Disasters: Coping Strategies and Survival

Editors' Note

The four chapters under Part IV deal with human responses to flood and erosion disasters in the chars and how people cope with and adapt to such events almost routinely. Two chapters (by Islam, and Hossain) report case studies from the Ganges/Padma and Brahmaputra floodplains; a third chapter by Paul et al. examines coping strategies of people to bankline erosion in the Lower Meghna estuary. Tod and Morshed describe the benefits of adopting small scale flood proofing measures by char communities toward reducing vulnerability and losses due to floods.

Shafi Noor Islam argues that riverine floods and erosions have historically caused significant impacts on society and economy of the chars in the Ganges-Padma river basin area. Based on inter-temporal data on migration and resettlement history of char dwellers, Islam recommends a comprehensive adaptive guideline for charland settlement and livelihood sustainability. The chapter by Bimal Paul et al. deals with coping strategies of people who are displaced by river bank erosion in the Lower Meghna Estuary. It was found that the affected households in the study area adopted coping strategies that are similar to the ones adopted by those in the floodplains.

The chapter by Babul Hossain examines the role of NGOs in providing pre- and post-flood support to char dwellers in the Teesta-Brahmaputra basin. Support given to rural infrastructure development and assistance in health care, and micro-credit for income-generating activities improved living conditions and quality of life of char dwellers. The author concludes that any future char development policy should consider housing as an essential component.

Finally, in Chap. 15, Ian Tod and Monzu Morshed examine the development and effectiveness of small scale flood proofing measures in riverine and coastal chars in mitigating the losses caused by flood. The authors conclude that flood proofing measures are an economically sound investment, effective in reducing vulnerability of char households in the event of floods.

Chapter 12
Floods, Charland Erosions and Settlement Displacement in the Ganges-Padma River Basin

Shafi Noor Islam

Abstract Floods and river bank erosions in Bangladesh have historically impacted the society and economy of the country. The flood and erosion disasters in the Ganges-Padma River Basin have caused displacement, in many instances frequently, forcing people to migrate every now and then. The objective of the chapter is to map the process of out migration of char people to various locations within the region and to develop a comprehensive adaptive guideline for charlands settlement conducive to sustainable livelihood for households that are victims of the cyclic displacements due to natural hazards.

Keywords Ganges-Padma River Basin · Floods · Charland erosion · Settlement relocation · Cyclic displacement and adaptation

Introduction

The deltaic land of Bangladesh is prone to disasters caused by floods and river bank erosion (Islam 2016). The Ganges-Padma River systems build up numerous charlands within the channels. For people living in the river basins, networks of rivers are a critical resource for their living, livelihood, culture and social life. However, periodic floods and erosions (see Chaps. 8 and 9) threaten human lives and bring extensive damages to land, crops and settlement almost on an annual basis. It has been reported that about one million people are affected by riverbank erosion each year in the country primarily through loss of land and homesteads (Haque and Zaman 1989; Elahi 1991); further over 12 million char people live in the charlands, struggle with monsoon floods and river bank erosion in the midst of their poverty (Schmuck 2001). This chapter presents responses to flood and erosion at the micro-level, as found in Purba Khas Bandarkhola Mouza in Char Janajat Union of Sibchar Upazila of Madaripur District within the Ganges-Padma Basin, particularly, focusing on local level migration and cyclic displacement pattern. An analysis of the settlement

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displacement and migration establishes a mobility pattern that illustrates an adaptive model typical of the charland displacement behaviour in the study area.

The problems of the char settlements relocation due to monsoon floods and river bank erosion in the large rivers remain relatively understudied. Key researchers in this area include Elahi (1989, 1991), Baqee (1997, 1998), and Mamun and Amin (1999). Zaman (1989, 1991) in his anthropological study argued that response to natural hazards varied in accordance with socio-economic background, ability to cope with their losses and resilience. Baqee (1998) points out that the settlements originate through the sponsorship of powerful elites and inevitably grow through a filtration process that involves gradual in migration by others. As a result, settlement in char areas, together with mutual interdependence and kinship support, establishes social structures based on a complex web of socio-economic relationships. Mamun and Amin (1999) studied perception of people in the vulnerable charlands and suggested a number of strategies to reduce their sufferings. Hassan et al. (2000) provided an overview of indigenous knowledge and practices of people while coping with river erosion and floods.

Objectives and Methodology

The study was designed to investigate the nature of charlands erosion and settlement relocation due to floods and erosion in the Ganges-Padma River Basin using Purba Khas Bandarkhola Mouza as a case study. The primary focus was char livelihoods and the cyclic displacement of people over a period of nearly ten years. The outcome of the study is expected to bring out patterns of settlement and migration over a period of over ten years that may be helpful for future charland policy and administration.

Both primary and secondary data have been used for the study. The primary data on charland erosion, settlement relocation, displacement, char livelihood, etc., were collected from the people of Purba Khas Bandarkhola mouza through participatory rural appraisal (PRA) and informal interviews. Field studies were carried out at three different time periods—first in 1997–1999, followed by a socio-economic survey in 2003 and a quick follow up in 2008. Complete enumeration of the households covering land holding pattern, tenancy, agricultural cropping, marketing, occupation, demographic features, literacy, etc., was undertaken in 2003 and 2008. Besides, two quantitative data based case studies were arranged with two different char families with experiences of cyclic displacement over the last 50 years in Char Janajat island of Ganges-Padma River channel. One case model of cyclical displacement in the charland of the river basin has been analyed in Fig. 12.4. An elderly member of each of the households provided chronological data and identified places of settlement relocation in different years and char livelihood information. These data and information were used to develop the cyclic displacement models. The times series remote sensing (RS) imageries from 1995 to 2008 and 2019 were used to investigate and compare the trends of charlands erosion and consequent settlement relocations.

The Study Area

The Purba Khas Bandarkhola village is in Char Janajat Union, located in the middle of the multi-channel Brahmaputra-Jamuna River. The *mouza*[1] is under Char Janajat union (area 31.94 km^2) in Sibchar Upazila of Madaripur District. The entire char is called Char Janajat, consisting of multiple revenue villages with an approximate area of 84.09 km^2 in 2003. Channels flow on both sides of the Char Janajat Island. Total population of the Char Janajat Union was 13,958 in 2003. The followup visit during 2008 was ensured the population figure estimated to be over 35,000. Due to endemic erosion, displacement and migration, it is often difficult to determine administrative boundaries of chars, leading to conflicts and disputes over newly accreted lands (see Zaman 1988).

The Padma and Arial Khan Rivers have a major role in the formation and subsequent erosion/accretion of Purba Khas Bandarkhola Village (Fig. 12.1). About 55% of the char inhabitants are farmers a small portion of them are *borgadar* or sharecropper. Other occupations include agricultural labour (11%), non-wage women labour (3%), petty trading (13%), transportation (5%), fishing (4%), regular salaried jobs (4%) and others (5%). There is a primary school, junior high school, post office,

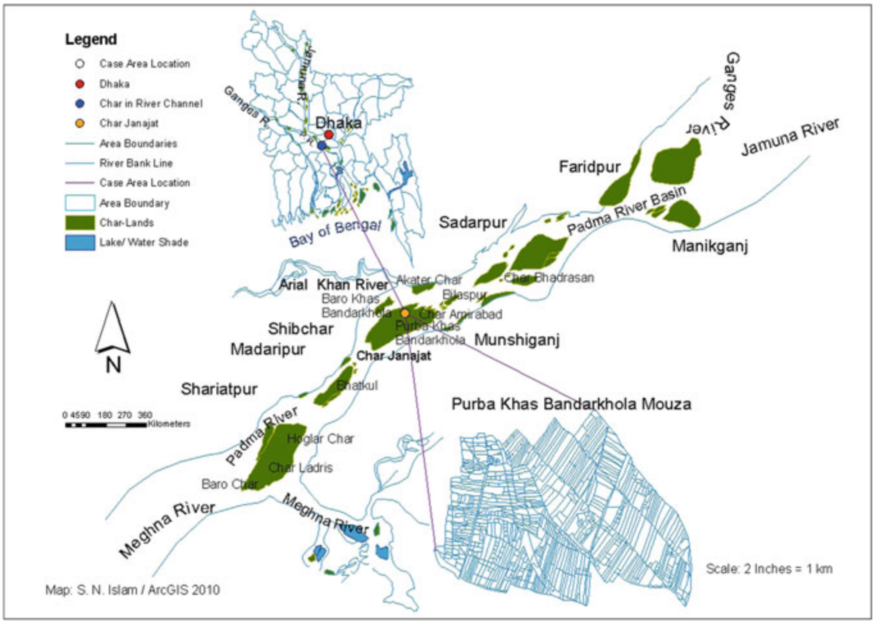

Fig. 12.1 Study village and surrounding chars. *Source* Islam et al. (2010)

[1] The word *mouza* refers to revenue unit in a cadastral map. Purba Khas Bandarkhola has multiple cadastral sheets. The study village is in Mouza sheet number 3.

mosque and a small market place Bazar in Char Janajat, but there is no health clinic in the char (Islam 2000; Ali 1980).

Floods and Its Impacts on Char Erosion and Livelihoods

The charlands are repeatedly affected by floods, with concomitant riverbank erosion by the shifting river channels (Ahmed 1956; Hassan et al. 2000; Hooper 2001). Almost all the charlands in the GBM catchments are inundated by floods nearly every year. The flow of the Brahmaputra-Jamuna is more erratic than that of the Ganges. In the rainy season, it brings down around 13 million tonnes of sediment per day (Coleman 1969; Schmuck 2001), resulting in new land formations in the Jamuna-Padma River channels. The adverse impacts of such floods and erosions are multi-dimensional—causing loss of land and homesteads, forcing people to migrate and making them endure losses of income and livelihood (Currey 1986; Zaman 1988; Haque and Zaman 1989). In sum, the endemic floods and erosions create food insecurity, threaten sustained livelihood and typically create poverty among a large segment of the floodplain populations, including numerous post-flood health risks (Islam 2006). The floods/erosions and displacement can thus be considered the major reason for persistent poverty in the char villages.

Over the years, an important trend found in Purba Khas Bandarkhola was fluctuation in settlement and population due to displacement and migration. In 1964, there were 371 households, the population being 3000. In contrast, during 2000, there were only 82 households, with a population of only 574; which increased to 173 households (population 1350) in 2008. In 2010, there were only 5 households with 35 people, suggesting that settlements and population in charlands are rather unstable and largely influenced by erosion and consequent displacement from year to year. The frequency of displacement varies from 1 to 9; 52% responded to have experienced displacement 7 to 8 times, while 38% got displaced over 9 times and moved within Char Janajat or to other adjacent chars (Islam 2000). In Purba Khas Bandarkhola, one household reported to have been displaced 17 times. In sum, people in the chars are constantly faced with displacement, livelihood insecurity and lack of access to health and basic needs such as food, safe drinking water and shelter.

The multipurpose Padma Bridge Project, which is under construction near the southern tip of Char Janajat, has generated a sense of hope for stability of the char due to river training work for the protection of the bridge itself. The multi-billion-dollar bridge project will bring stability in the channel through protective works on both sides of the river (see Fig. 12.2).

The bridge project has also brought new opportunities for off-farm employment for people in Char Janajat. The field study carried out in 2017 reveals that 29% of those interviewed expect protection from future flood and erosions due to protective works. Close to 10% of the respondents felt that their employment and incomes will now be more secured with project works that would bring changes in their living

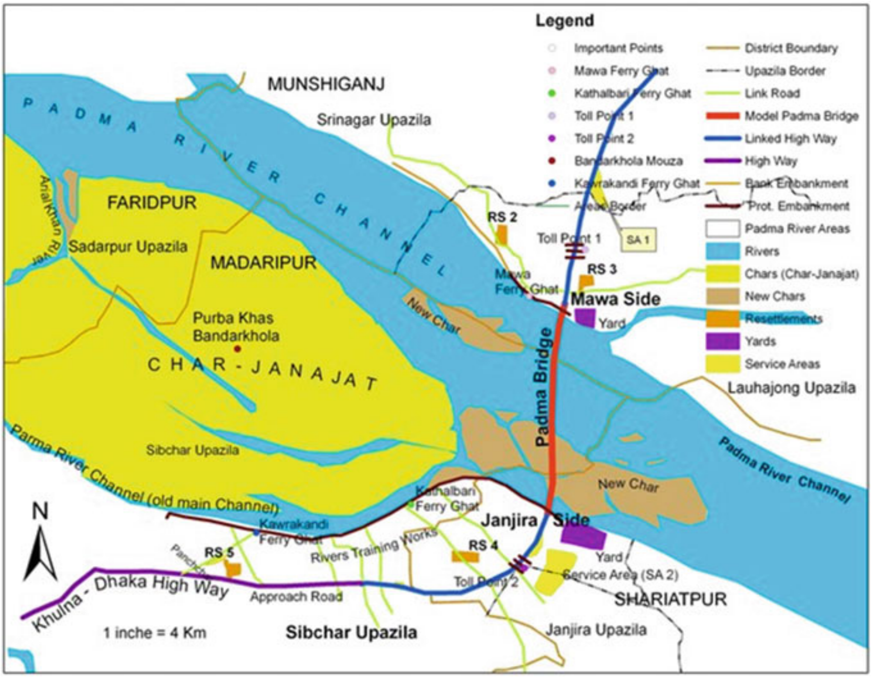

Fig. 12.2 Location of Padma Bridge vis-à-vis Char Janajat. *Source* Islam et al. (2011)

conditions. Another 20% reported increased interests in charlands by tourists due to the iconic bridge and other facilities established at the bridge site.

Settlement and Relocation Patterns

By using inter-temporal data collected during various phases of data collection in Purba Khas Bandarkhola, it was possible to reconstruct the changing settlement over a period. In Fig. 12.3**,** the top left (1970) and top right (1980) represent the time frame when settlement pattern was clustered. Between 1988 and 1990 (middle right and middle left, respectively), settlement pattern was random and clustered as well. In 2000 (bottom left) and 2008 bottom (right) show scenarios of settlement patterns, which are random, often semi-clustered. The changes in the settlement patterns were function of erosion overtime and availability of land for re-housing. As a result, varying population density was reported during the study and subsequent revisits. For instance, the settlement density in was 189/km^2 in 1964, 163/km^2 in 1970, 117/km^2 in 1974, 92/km^2 in 1980, 101/km^2 in 1985, 61/km^2 in 1988, 72/km^2 in 1990, 59/km^2 1998, 48/km^2 in 2000, 89/km^2 in 2003, 102/km^2 in 2008, 29/km^2 in 2009 and the density rate has gradually decreased and it is only 3/km^2 in 2010.

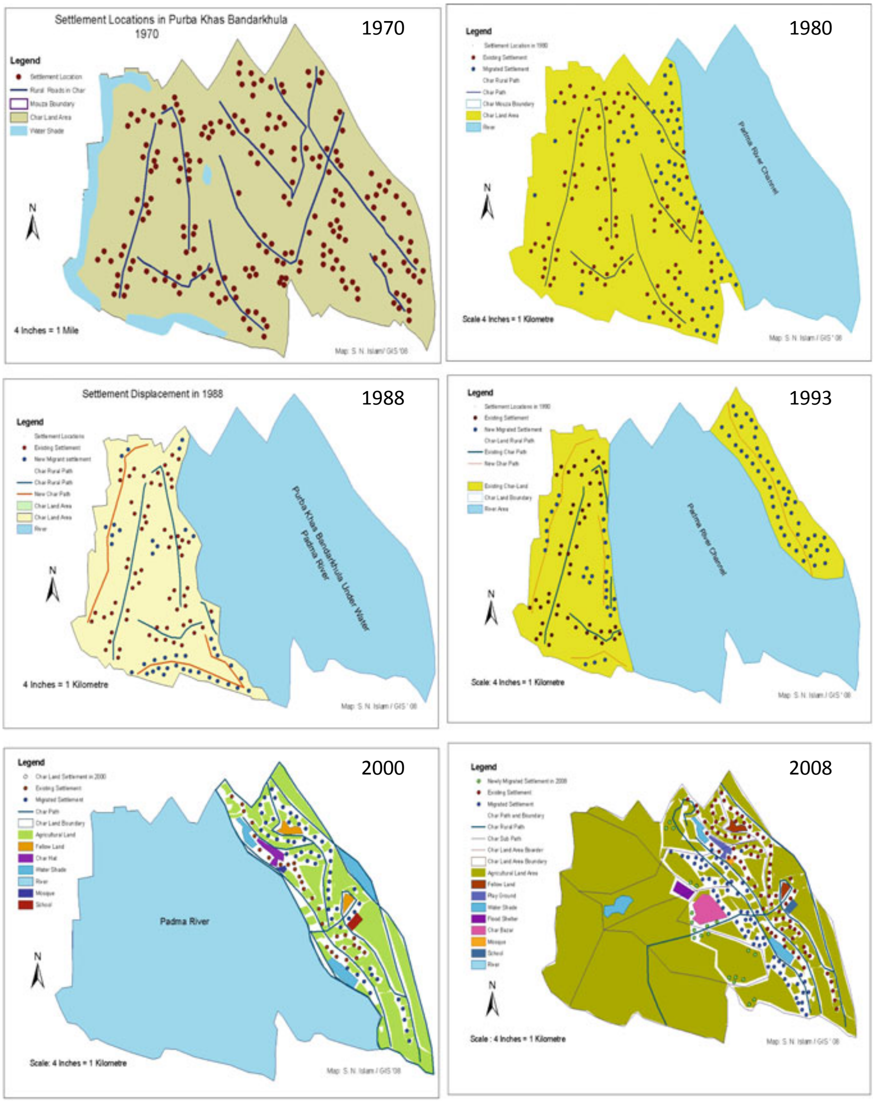

Fig. 12.3 Population density and settlement patterns (1970–2008). *Source* Islam et al. (2011)

Therefore, population density in the char settlements depend, among others, on land availability and to a greater extent on kinship support. The increase and decrease in density also depends on floods and erosion impacts and displacement at any given time (Kabir 2006).

Cyclic Displacement of Omar Ali: Case Analysis (1945–2020)

Figure 12.4 describes the cyclical displacement of Omar Ali Sheikh and his family over a period of 46 years. Omar Ali Sheikh, son of Abdul Gani Sheikh, was living in Purba Khas Bandarkhola (Mouza Sheet 2). His father settled down at Purba Khas Bandarkhola in 1945. It was good and comfortable life for them because they had agricultural land and he had 10 family members. They cultivated varieties of agricultural crops that were enough to survive for the whole year. The floods and other natural calamities were not creating any massive damage to their land property and resources. Later on, Omar Ali relocated to another bigger plot in the same char with all 10 family members (4 brothers, 4 sisters and parents). He built 4 houses (tin-shed), his occupation was agriculture and farming. His land area was 3 acres; it was enough for the supply of food grain for the entire year.

In 1964, Omar Ali's houses were affected by massive flood and river bank erosion. He then decided to move from his father's land and relocated 5 km away to the south Char Janajat in 1974. Only his eldest brother stayed in their original village, but eventually moved to Char Janajat (west) in 1987. In 1990, he relocated again to Kathalbari and returned to Char Janajat in 1996. He returned to his original home place in 2008. The relocation and cyclical migration were largely due to erosion and displacement at various times and available support and assistance from kin groups

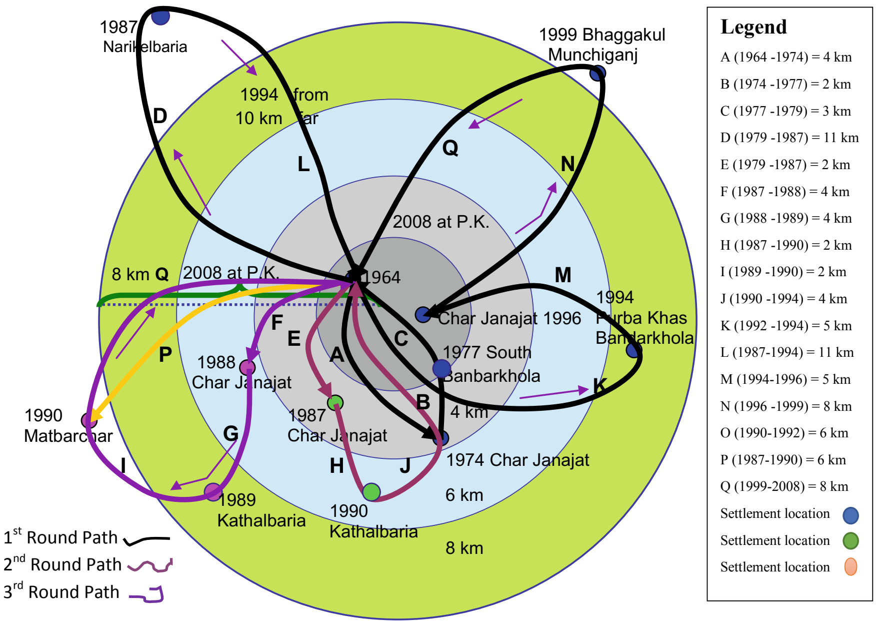

Fig. 12.4 Omar Ali and his family's displacement and migration history in and around Char Janajat. *Source* Author 2020

at different locations. This is a very common pattern associated with displacement and migration among char people (see Chap. 13).

The second brother also relocated in 1988 to Char Janajat (West) after the massive flood, which totally damaged his house. He then shifted to Kathalbaria union in 1989 and lived for only one year and then shifted to Matbarchar to his brother's place in 1990; he stayed there for only 10 months and again returned to his ancestral land in Purba Khas Bandarkhola in 2008. The 3rd brother also shifted in 1990 to Matbarchar of Shibchar Upazila, which is 8 km away from Purba Khas Bandarkhola. He continued living there permanently. Omar Ali came back to Purba Khas Bandarkhola in 1977 and again shifted in 1987 to Narikelbaria, which is 11 km from Purba Khas Bandarkhola and located in Sadarpur upazila of Faridpur district. Omar Ali stayed in Narikelbaria for the 7 years. Due to social, economic and kinship grounds, he again decided to return to Purba Khas Bandarkhola mouza when the char re-emerged as a process of accretion. Omar Ali was still living there during time of the survey permanently. Omar Ali and his family members were displaced and/or migrated in and around Char Janajat area 17 times within 46 years. The Omar Ali family travelled a distance of 87 km in the cyclic displacement and resettlement with annual average of 1.97 km and mean average distance of 5.11 km.

Although Omar Ali's displacement experience may appear high, it is not uncommon in the char areas. Haque and Zaman (1989, Tables 3/4) reported that 12% of those displaced (N = 321) in Kazipur Upazila, about 30 km upstream of Char Janajat, moved 13 times or more over a period of 40 years. In Kazipur, 33% of those displaced moved between 1.5 and 8 km distance in their last reported displacement. These patterns confirm that displacement is more common in the chars with short distance migration despite unstable land and insecure life styles and the environment. The study further confirms that charland people want to live and work within the char environment. The tasks for policy-makers and planners are to find a stable and sustainable char cultural life.

A Conceptual Model for Charlands Settlement and Livelihoods Sustainability

The discussion so far and evidence presented provide narratives of direct, indirect, cumulative impacts of floods and riverbank erosion on the riverine charlands. The charland land use, land erosion and land losses, soil fertility deprivation and decrease of rural surface water sheds, provisions for employment, sustainable livelihoods and so on should be important issues for future planning consideration, more particularly, in the chars in view of the potential impacts of climate change in char areas (see Chap. 11).

Figure 12.5 presents a conceptual model, taking a holistic approach to protection of natural resources and sustainability, involving charland ecosystems and social, economic, health and cultural aspects ensuring char livelihood sustainability.

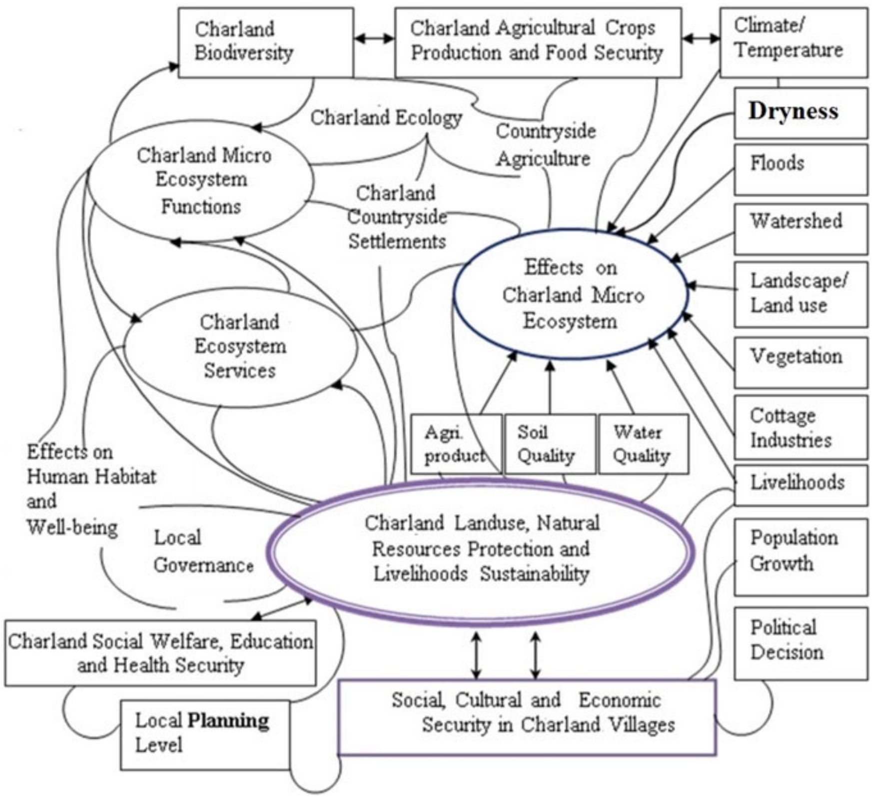

Fig. 12.5 Conceptual model for charland settlement and livelihoods. *Source* Author 2020

This conceptual model for charland use and sustainability is dependent on many factors and careful planning that remains to be tested. However, the comprehensive mapping of the inter-related factors, processes and institutions should be helpful for future planners. Critical to such planning and management approach are—for instance, (i) improved protection of charland use minimizing conflicts over land tenure rights; (ii) development of a strong databank on charlands; (iii) use of GIS and remote sensing techniques in charland data analysis, visualization, mapping, planning and modelling; and (iv) community inputs and participation in designing local adaptive strategies using indigenous knowledge and skills for capacity building. Finally, more char studies and research should be encouraged by establishing new institutions and/or centres in public universities for graduate studies and training with a multidisciplinary approach for capacity building and good governance. Any future char development policy must consider these factors for sustainable settlement and livelihoods in char villages.

Acknowledgements The chapter incorporates ideas and findings of research I have jointly carried out with my colleagues Shilpa Singh, Hashibush Shaheed and Shouke Wei (see Islam et al. 2010). I acknowledge their contributions and remain thankful for their support as well as thanks to the char dwellers those gave me a lot of information concerning char settlement and livelihoods issues.

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Chapter 13
Coping Strategies of People Displaced by Riverbank Erosion in the Lower Meghna Estuary

Bimal Kanti Paul, Munshi Khaledur Rahman, Thomas Crawford, Scott Curtis, Md. Giasuddin Miah, Rafiqul Islam, and Md. Sariful Islam

Abstract Riverbank erosion is common as a disaster event in riverine Bangladesh. It not only affects people living in inland char areas and along the major braided rivers, but also the coastal areas. Charlands are characterized by both erosion and deposition. When the rate of deposition exceeds the rate of erosion, over time, some chars become attached to the mainland, particularly, in the coastal areas. While coping strategies of displaced people in inland areas have been widely studied, relatively little is known about such strategies for people displaced by riverbank erosion in coastal Bangladesh. This chapter addresses this gap via a questionnaire survey conducted among 413 households in 15 villages of Ramgati Upazila in the Lakshmipur District. The Survey was followed by Focus Group Meetings and Key Informant Interviews. All study villages are located along the eastern bank of the lower Meghna River, around the main outlet of the Ganges–Brahmaputra–Meghna drainage basin. The survey revealed that people of the study area mitigated impacts of riverbank erosion by adopting various coping strategies, some similar to those adopted by erosion affected people of inland areas and others different. Finally, a number of recommendations are made to assist those adversely affected by riverbank erosion in the lower Meghna River estuary in coastal Bangladesh.

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Introduction

Bangladesh, a country of rivers, has been formed by accumulation of sediments carried by the combined flow of the three mighty rivers: the Ganges (Padma), the Brahmaputra (Jamuna), and the Meghna (GBM) Rivers.[1] These rivers are morphologically highly dynamic, forming islands or chars between their braiding channels, and eroding these depositional features as well as the major riverbanks. The accretion and erosion are not confined to inland areas only, but extend to estuary and coastal areas of the country. Of these two processes, the latter has dramatic consequences in the lives of local people, displacing between 200,000 and up to one million people per year (Alam et al. 2017; Elahi et al. 1991; Ferdous et al. 2019).

Of the 64 districts[2] of Bangladesh, eight (Kurigram, Gaibandha, Jamalpur, Bogra, Sirajganj, Tangail, Pabna, and Manikganj) lie in the erosion-prone zone along the Jamuna River, another eight districts (Rajbari, Faridpur, Pabna, Manikganj, Dhaka, Munshiganj, Shariatpur, and Chandpur) along the Padma River, and five districts (Barisal, Bhola, Chandpur, Lakhsmipur, and Noakhali) along the lower Meghna River. Around 30–40% of the country's population live in these erosion-prone areas (Naz 2019).

Chars are dynamic geomorphological features characterized by both erosion and deposition and are extremely sensitive to changes in river conditions (see Chaps. 8 and 9). This makes the erosion process highly unpredictable and it is not always compensated by accretion. When the rate of deposition exceeds the rate of erosion, some chars over long time connect with the mainland, particularly, in coastal areas. While coping strategies adopted by people displaced by major floods and riverbank erosion within the inland have been widely studied (e.g., Hutton and Haque 2003, Islam et al. 2013, Mamun 2016, Zaman 1991), little is known about such strategies for people displaced by erosion of chars attached to the mainland in coastal areas of the country. The present study addresses this research gap through the use of primary data collected from 15 selected villages of Ramgati Upazila in Lakshmipur district, Bangladesh. The study area is located along the eastern bank of the lower Meghna River at the main outlet of the GBM drainage basin. The selected villages are most vulnerable to riverbank erosion and other natural disasters. The objective of this study is to examine the ways residents of the study area have coped with the impacts of most recent riverbank erosion. The study was designed from a realization

[1] This research was funded by the U.S. National Science Foundation (NSF) grant number 1660447.

[2] A district, which includes several Upazilas (sub-districts), is the second largest administrative unit in Bangladesh, with an average population of 2.5 million. A union is the lowest administrative unit comprising a number of villages.

that riverbank erosion in coastal areas is different from inland erosion, and therefore, residents there would likely cope differently with such events. An understanding of these differences would help in developing public policies toward providing support to the people living in coastal areas who are faced with the threat of continuous displacement due to riverbank erosion.

One striking difference between the two types of riverbank erosion is in the frequency of occurrence. Riverbank erosion in inland areas of the country usually occurs once a year, during the rainy season (June–September), when heavy monsoon rains cause flooding along the major rivers (Ferdous et al. 2019); however, some studies have argued that erosion happens more during the period when flood water recedes (see Zaman 1988). In contrast, riverbank erosion in coastal areas can occur any time of the year. Thus, coastal residents vulnerable to erosion live with the perpetual risk of losing homesteads, agricultural land and, with these, their livelihoods a well. Although riverbank erosion accelerates during the rainy season due to the force of excessive freshwater discharges from upstream, coastal areas are prone to erosion and inundation regularly by diurnal high tides. In such areas, erosion further intensifies if high tides occur during a full moon; or are accompanied by high winds and waves (Rahman et al. 2015). Another significant difference is that coastal areas are occasionally hit by violent tropical cyclones and associated storm surges,[3] which are further amplified if these coincide with the normal diurnal high tide. Catastrophic events like these can cause rapid riverbank erosion in the coastal areas. It has been predicted that cyclones and storm surges in coastal areas would become more severe and occur more frequently in the near future as climate change impacts become more pronounced there over time (Rashid and Paul 2014; also see Chap. 11).

It is to be noted that a disaster that initiates other disasters is called the primary disaster, and a disaster caused by the primary disaster is often referred to as secondary disaster (Montz et al. 2017). Inland riverbank erosion is primarily caused by annual flooding, and the intensity of erosion is exacerbated by disastrous floods that occur once every three years or so. Thus, riverbank erosion in inland areas can be considered a secondary hazard, next to flood. In coastal or estuarine areas, riverbank erosion is mostly a primary hazard. The only exception is when tropical cyclones are accompanied by storm surges since both can cause riverbank erosion in coastal areas. In such a case, riverbank erosion can be considered a tertiary hazard. The present study examines the perception of people in sample areas regarding riverbank erosion and also discusses coping strategies adopted by those who have most recently been affected by riverbank erosion.

[3] A severe cyclone occurs once almost every three years in Bangladesh (GoB 2008).

Research Methods

The Study Area

The study area comprises 15 villages in four unions (Char Alexander, Char Algi, Char Badam, and Char Ramiz) of Ramgati Upazila in the Lakshmipur district. It is located along an approximately 20 km stretch of the eastern bank of the lower Meghna River in Bangladesh.

The study area covers 70 sq.km, with a population of around 40,000, according to the 2011 Population Census of Bangladesh (BBS 2015). As a part of the Meghna estuary, the study area is characterized by low elevation and rapid geomorphological changes. Consequently, riverbank erosion is an acute problem and has been particularly so since 2008. Our analysis of shoreline change using Landsat imagery reveals that the mean annual erosion rate from the riverbank to inland is 113 m per year for the period 2008 to 2018 in the Ramgati study area.

Based on geomorphological and ecological conditions, the coast of Bangladesh can be divided into three zones: (i) the southwest, dominated by the Sundarbans mangrove forest; (ii) the Meghna estuary along with the vast active delta in the central portion of the country; and (iii) the eastern coastal lowlands or the Chittagong coast (Rashid and Paul 2014). The study area falls within the conical and funnel-shaped Meghna Estuary, which stretches from Chandpur in the north to the southern-most part of Bhola Island. Due to its shape, storm surges generated by tropical cyclones here are higher compared to those in other coastal areas of Bangladesh. It is to be noted that Bhola, one of the 64 districts in the country, is the largest island in the country. The study area is located approximately 50 km southeast of Chandpur (Fig. 13.1). Three large islands (Bhola, Hatiya, and Sandwip) and several small ones exist in the estuary. These islands play a key role in distributing the huge flow of sediment in the Bay of Bengal.

The Meghna Estuary is the most productive fishing ground in Bangladesh. Expectedly, fishing is the primary occupation of majority of people living in the study area, and also the secondary occupation of many more residents. Additionally, a considerable number of people in the study area are employed in fishing-related trade; such as buying and selling fish to local and distant markets, transporting fish to the markets, and making/repairing fishing boats and nets. Most people engaged in agriculture are marginal farmers. Although rice production continues to be the mainstay in agriculture, the production of soybean has been popular in recent years.

As in other coastal areas, access to education, health, and other basic services in the study area is lower than the national average. Also, poverty rate here is higher than the national average (Rashid and Paul 2014).

The study area experiences multiple hazards. In addition to riverbank erosion, it is subjected to tropical cyclones, storm surges, flash and riverine floods, water logging, thunderstorms, nor'westers, lightening, and tornadoes. One of the most severe cyclones associated with storm surges hit the study area in 2007, followed by other minor ones in recent years. However, the slow and gradual erosion of

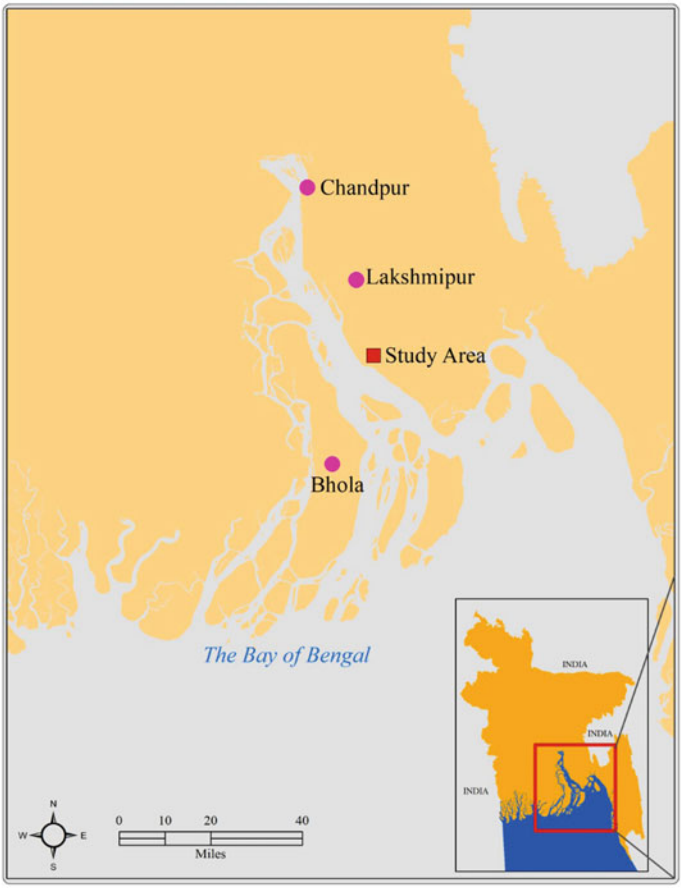

Fig. 13.1 Study area within the Meghna Estuary. (*Source* Bimal Paul)

banklines continues as an endemic disaster, making people in the study area landless and homeless. Finally, the study area is highly vulnerable to global climate change and associated sea-level rise (see Chap. 11).

Sources of Data

Quantitative as well as qualitative research methods were used in the study. Quantitative data were collected through a structured questionnaire survey covering randomly selected 413 households during April–May, 2018. The survey questionnaire was approved by the Institute of Review Board (IRB), Virginia Polytechnic Institute and

State University (VPISU), Blacksburg, Virginia, USA.[4] Further, qualitative data was collected through six different focus group meetings (FGMs) and 14 key informant interviews (KIIs). All of the FGMs were conducted during the summer of 2018; five of which were moderated by three members of the research team, and the remaining one by a local woman for a female-only session, aimed at understanding gender dimensions of responses. In all, 67 adults participated in the FGMs, representing various socio-economic and occupational categories. Nearly, 50% of the participants were females. All FGMs were held in local primary schools and lasted for approximately two hours in each case. Discussions were focused on riverbank erosion, including its extent, causes, and impacts, with emphasis on migration inland and to chars.

Similar to the FGMs, all key informant interviews were held during the summer of 2018. The informants included males and females representing different occupational categories, local elected representatives, including the member of the *Jatiya Sangsad* (Parliament) from the study area. Each semi-structured interview, lasting over an hour, was guided by a set of questions relating to issues on lower Meghna riverbank erosion and migration. Responses obtained during the FGMs and KIIs were recorded and transcribed.

Survey Results and Analysis

Unlike many past studies on coastal migration in Bangladesh (e.g., Bernzen et al. 2019; Chen and Mueller 2018), the present study follows the official definition of migration provided by the Population and Housing Census of the Government of Bangladesh. It defines migration as the movement of persons who change their place of residence, for reasons other than marriage, for a period of six months or more.[5] Movement within a district is not considered migration (BBS 2011). Given the Bangladesh government's definition, the household survey indicated that out-migration from the study area is negligible (the FGMs and KIIs support this finding). Survey data also revealed that 192 (or 46%) of the 413 respondent households had moved their homesteads due to riverbank erosion, job search and other miscellaneous family reasons since 2008. The year 2008 is used as a reference year because the study area was affected by erosion and the catastrophic 2007 Cyclone Sidr. This was mentioned time and again by respondents during the FGDs.

Among the 192 respondent households who moved, 184 were found to relocate within the study area due to the recent riverbank erosion, occurred during 2008–2017. Most of the relocated households were found within 0.7 km of the Meghna River. Among the 184 households, 128 (or 70%) have moved one time, and the remaining

[4] It was part of an internal requirement for compliance with research ethics guidelines.

[5] However, unlike voluntary migration, riverbank erosion involves forced migration; the displaced families are often categorized as internally displaced persons (IDPs), often associated with environmental displacement. Despite differences among academics and policy-makers, IDPs and forced migration due to riverbank erosion are in essence two sides of the same coin (see Zaman 2019).

30% had moved two or more times (between 208 and 2017). None of the households moved outside Lakhsmipur district and thus may not be considered migrant as per the official definition. However, as indicated earlier, this official definition precludes the forced migration and hence not helpful in appreciating the delicate issues of displacement, migration and resettlement (see Zaman 2019).

Profiles of the Respondents

Of the 413 selected households, the socio-economic profiles of the 184 respondents who relocated since 1984 due to bank erosion and displacement and their coping strategies are discussed below.

It appears that fishing is the primary occupation for over 27% of all respondents, followed by farming (about 20%). Seventeen household heads (nearly 10%) were engaged in both fishing and farming. Twenty-nine respondents (nearly 16%) were engaged in small business, many of them also associated with fishing trade. Twenty-one household heads had salaried jobs. Other occupations included agricultural/non-agricultural day labor and homemakers.

Most household heads were between the ages of 35 and 45, nearly 35% being over 45 years. Family sizes varied between two and 15, the average family size being around six. Literacy rate among the respondents was 32%, with a generally low level of education (only seven percent studied beyond the tenth grade). About a third of the households earned an annual income equivalent to US $500, only around 10% earning more than that.

The FGMs and KIIs suggest that nearly 90% of households had no agricultural land at the time of the survey. Most of the remaining 10% had some land for cultivation. Thus, the landless proportion is much higher than the national average in Bangladesh, which is typical for coastal regions in Bangladesh (Paul and Dutt 2010).

Perception on Riverbank Erosion

The respondents cited 13 different causes of riverbank erosion. Many of them specified more than one cause of such erosion (Fig. 13.2). The largest number of respondents (88%) mentioned that the formation of mid-channel chars in the Meghna River is the leading cause of riverbank erosion in the study area. These chars divert the river flow toward the east coast, which intensifies bank erosion. The second most frequently reported (74%) reason was the fast and strong flow of river water during the peak of monsoon season when the lower Meghna River carries a large volume of water from upstream due to heavy rain in the GBM basin and melting of snow in the Himalayas.

The third important cause reported (39%) was high and strong tide. Fourth, many of the respondents (29%) believed that the riverbank erosion was caused by the “will

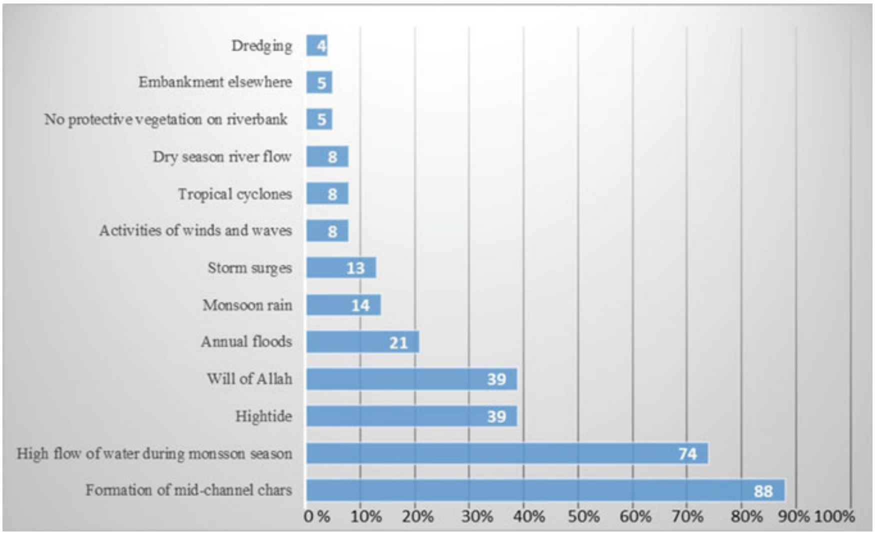

Fig. 13.2 Perception on riverbank erosion by respondents. *Source* Field Survey 2018

of Allah (God)", reflecting their world-views about erosion. Such responses are also reported in similar studies on erosion in the Jamuna floodplain (see Haque and Zaman 1989; Zaman 1994). Other causes in descending order are: direct monsoonal rain around riverbanks, storm surges, cyclone, absence of protective vegetation on riverbank, embankment elsewhere along the river, and dredging in the lower Meghna River. Some respondents did mention of the impact of construction of embankment upstream for flood control purposes.

Coping Strategies for Riverbank Erosion

Riverbank erosion occurs throughout the year in the study area. Thus, for the residents there, particularly, those who live along the bank of the lower Meghna River, erosion poses a serious threat on a continuous basis. However, according to most of the respondents, the most intense erosion occurs during the monsoon season (June–September), and the least in the winter months or dry season. During the winter season, discharge of the Lower Meghna River is very low. This often results in the problem of salinity intrusion into the study area, particularly, during high tides.

Although 184 respondents have relocated since 2008, not all of them lost their homes due to riverbank erosion. Twenty-two relocated because of fear of homestead loss, and three moved because of loss of cropland. Fifty-five (or 30%) respondents relocated because of fear of loss of both house and cropland. The remaining respondent households relocated because their homes and homestead lands were lost to river.

In addition to loss of homes and crop lands, respondents also reported loss of livestock and household assets. These losses result in significantly increased economic hardship through food insecurity and lack of employment opportunities, particularly, for the landless laborers and small and tenant farmers. Because of continuous riverbank erosion, several landlords became homeless and landless over time. Still, they are reluctant to leave the study area. One respondent in one FGM said, 'We want to live close to the river because it provides livelihoods along with fertile soil, which is a gift of the river.'

The respondents tried to reduce impact of riverbank erosion on them by adopting various coping strategies. Three-fourths of them tried to cope by taking financial loans from formal sources (e.g., banks and the local cooperative associations) and/or informal sources such as local money lenders, often at very high interest rates. Over 23% respondents sold household assets like jewelry, utensils, and furniture, and around 18% were forced to sell livestock, poultry, and duck. Only eight respondents sold lands. Distress selling of assets is common in overcoming hardships caused by natural disasters in rural Bangladesh (Alam et al. 2018; Haque 1988; Haque and Zaman 1989; Zaman 1991). As a coping strategy, 30 respondents (16%) changed their occupations from part-time fishing to full-time fishing or contracted to do off-farm work due to reduced availability of land and/or farming was not that viable for earning a living.

Nearly 63% of all respondents received emergency assistance from their relatives, friends, neighbors, and other community members. Like other parts of rural Bangladesh, social bonding and networks are very strong in the study area. Members of kinship and other community groups were found to provide households affected by erosion with food, clothing, and other necessary items; in particular, when they became homeless due to erosion. There were numerous instances of loaning money on easy terms. In short, people of the study area were heavily dependent on social networks and connections during crisis periods, including riverbank erosion. These networks encourage community members to work together and promote trust, commitment, and loyalty to the community. Some of the more secured households allowed displaced households related to them (sometime, unrelated members of the *samaj*) to build residential structures on their available homestead land. This was one key reason why many of the adversely impacted households did not migrate to distant places.

Table 13.1 shows that 57 households (nearly 31%) purchased new land after most recent relocation, while 48 of them (or just over 26%) respondents relocated to the properties of community members like neighbors, relatives, and friends. The FGMs and KIIs suggest that a large number of the displaced were allowed to stay on these properties for two to three years, after which they would have to move (also see Rashid 2013a, b). In addition, 27 (nearly 15%) resettled temporarily on lands provided by community members like local politicians, businessmen, and wealthy individuals. Table 13.1 also reports that 33 households (nearly 18%) built houses on their own land purchased years before their houses were eroded by the river. The remaining 19 respondents (10%) resettled on government land or in rented houses in nearby marketplace within the study area. No one was reported to have informally squatted

Table 13.1 Post-relocation support for resettlement

Type of location	Number (percentage)
Land of relatives, neighbor, and friends	48 (26.09)
Land of community members	27 (14.67)
Land purchased before most recent relocation	33 (17.93)
Purchased new land after most recent relocation	57 (30.98)
Others	19 (10.33)
Total	184 (100.00)

Source Survey data 2018

on land; or built house on the embankment along the lower Meghna River eastern bank.

The survey data suggest that around 41% of homeless respondent households relocated to the properties of others within the study area, probably because they were unable to buy new land to rebuild houses. Such resettlers are commonly known as *uthuli,* who receive mutual support and help from local *samaj* organization and kin groups in the process of resettlement (see Zaman 1988). Many of these households were also unable to buy materials to construct houses. Once again, community members helped them by providing labor, building materials, and cash so that the displaced could rebuild their houses. One respondent in a KII reported that he has allowed one of his relatives to build a temporary house in his backyard. When asked the reason for permitting a temporary house on his property, he replied, 'When I was little, the river was almost 15 km away from our house. Now, it is just 1.5 km away. In near future, we may ourselves become victims of riverbank erosion. At that time, we may need similar support we are rendering now to the victims of such erosion. We do not provide support to receive similar help in near future, but we are very sympathetic to their circumstances because we treat them as members of our extended family.'

Apart from help of local people, respondents received certain financial and emergency assistance from local and national government institutions after being displaced by riverbank erosion. One public sector initiative providing such support is called the *Guchchha Gram* (Cluster Village) Project. The main purpose of the project was to resettle the landless whose houses were destroyed by tropical cyclone, storm surge, or riverbank erosion. By dint of this project, some households losing their homes due to riverbank erosion, became residents of these cluster villages. Some were found to relocate on government owned *khas* land. Another program is known as the Vulnerable Group Feeding (VGF)[6] that provided each fishermen's family 30 kg of rice per month for three months during the lean period, particularly, when harvesting *hilsa* fish is legally forbidden for spawning and preservation. Unlike

[6] The VGF program was initiated in 1975 and later renamed the Vulnerable Group Development (VGD). The objective of the program was to help poor families, particularly their women members.

in the case of other natural disasters, particularly, flood and cyclones, respondents affected by riverbank erosion here did not receive any assistance from local, regional, national, or foreign/international humanitarian organizations. Riverbank erosion and displacements caused by such disasters have not received due attention from policy perspective and the urgency for relief and rehabilitation of the displaced population has not been properly recognized. Thus, the displaced households try to survive and sustain with support from relatives, friends, and community members (see Haque and Zaman 1989).

Summary and Conclusions

People of the study area mitigated the effects of riverbank erosion by adopting manifold coping strategies, some similar to those affected by erosion around inland areas and some dissimilar to those. Selling household assets and borrowing money from local money lenders or members of social networks are common coping strategies for victims of both inland and coastal riverbank erosion. Another common strategy is change of occupations after being displaced by the disaster (e.g., Zaman 1988). Irrespective sof geographic location, most of the displaced households prefer to live close to the rivers or in the vicinity since they expect to have employment opportunities there. Also, they hope, by staying close to the eroded land, they would find it easier to reclaim that land if and when it re-emerges through the process of accretion (Sultana et al. 2019; Zaman 1991).

Several studies (e.g., Islam et al. 2013; Zaman 1991) have reported migration to be an active coping strategy for people vulnerable to inland riverbank erosion. One reason for this could be the lack of employment opportunities in affected areas in the aftermath of the disaster. Besides, the affected households might get interested in the diversification of household income. By arranging for the migration of one or more members of the household to various urban centers where they could obtain gainful employment, the household in question hopes to earn some additional income, which would come in handy during future crises.

The present study found hardly anybody from the erosion affected households migrating to distant places for work to cope with the impacts of the most recent event of riverbank erosion. Important among the reasons for this are, the availability of various natural resources for engaging in alternative employment opportunities, strong social ties providing support during disasters and a sense of attachment to the 'place of origin.'

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Chapter 14
Role of NGOs in Post-Flood Rehabilitation in Chars

Babul Hossain

Abstract This study seeks to investigate the role of non-governmental organizations in post-flood rehabilitation in some char areas in Bangladesh, for which relevant information has been collected from local people in the way of a case study. It was found that dependence on traditional agriculture and day labor, fishing, low level of education and income, fragile housing condition and sanitation facilities, small landholdings, etc. characterize the socioeconomic condition of the respondents. A number of NGOs played a significant role in improving living conditions and quality of life of the people living in the study area. These NGOs provided loans to the char people through a number of micro-credit programs and helped with developing housing and sanitation facilities, initiating various income-generating activities, supporting miscellaneous agricultural activities and participating in certain infrastructure development programs for the char communities. Although people within the study area reported in general to have benefited from NGO activities, they nevertheless considered the interest charged against loans to be relatively high.

Keywords Flood risks · Flood response · Post-flood relief and rehabilitation · NGO activities

The Context and Objectives

Bangladesh is a flood disaster-prone country, in terms of both number of people affected and loss of properties. Thousands of people living in char areas are affected by flood every year. Therefore, apart from government programs, services provided by NGOs are crucial to the life and livelihood of char people, which have been reported by many studies (Hoque 1995; Hossain and Sakai 2008; Zaman 1993; Paul and Hossain 2013; Martin and Taher 2001; Haque 1993, 2000; Pearce 1991; Majid et al. 2013; Jayaraj 2007; Audefroy 2010). Most of these studies dealt with overall issues of poverty, very few discussing in particular the pros and cons of post-flood rehabilitation programs in the country. The present study purports to fill

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some of this gap by analyzing the role of non-government organizations in post-flood rehabilitation during the 2017 floods, bringing into focus the successes as well as drawbacks of their programs.

The severe flood of August 2017 affected Bangladesh with record high water levels (Philip et al. 2019). According to the Ministry of Disaster Management and Relief (MoDMR), this was the most severe flooding experienced by the country over at least the last forty years (Philip et al. 2019). It significantly disrupted life and livelihood activities of the people. As many as 31 districts among the total of 64 in the country were affected significantly (DDM 2017). Around 6.9 million people were affected (Philip et al. 2019), with 121 people dead (Nirapad 2017). Apart from these, crop damage, disruption of communication and education, health issues, food problems, drinking water crises, and massive displacement of the affected people were observed in the flood-affected areas.

Along with the government, a number of NGOs came forward to help the flood-affected people and extended help in coping with the disaster. There are several NGOs working in the study villages such as SKS, GUK, SHACO, BRAC, and ASA (Portal 2018), each one having had activities concerning the flood in 2017. These activities covered three different phases; i.e., preparedness prior to flood, emergency response and evacuation during flood and rehabilitation in the aftermath of flood. The NGOs were found to be engaged mainly in preparatory meetings, training programs and setting up a number of shelters to be used at the time of disaster. During the flood of 2017, they were also found to rescue people, provide CI Sheets[1] to the affected people, supply food and non-food items to them, extend financial help, and supply household accessories as well as medicines. Side by side, with provision of micro-credit, they assisted in house reconstruction, income-generating activities, infrastructure development, cleaning of ponds, etc. Thus NGOs have played a vital role in post-flood rehabilitation in the study area. An important question in this regard is the degree to which their role can ensure sustainability of the livelihoods of the people there. This chapter explores the impacts of NGO activities relating to post-flood rehabilitation in the study area.

Study Area and Methodology

The district of Gaibandha, a flood-prone area in the north-western part of Bangladesh, was chosen as the geographical area for the study. It is located in the Teesta-Brahmaputra river basin. Two villages were selected from two separate *upazilas* (subdistricts). The study villages are riverine chars and isolated from the mainland (Fig. 14.1). Apart from reviewing secondary literature, the current study collected pertinent information by conducting a questionnaire survey, participant observations, focus group discussions (FGDs) and key informant interviews (KIIs) in the selected char villages. Based on the objective of the study, two sets of structured interview

[1] Corrugated iron sheets, for constructing house.

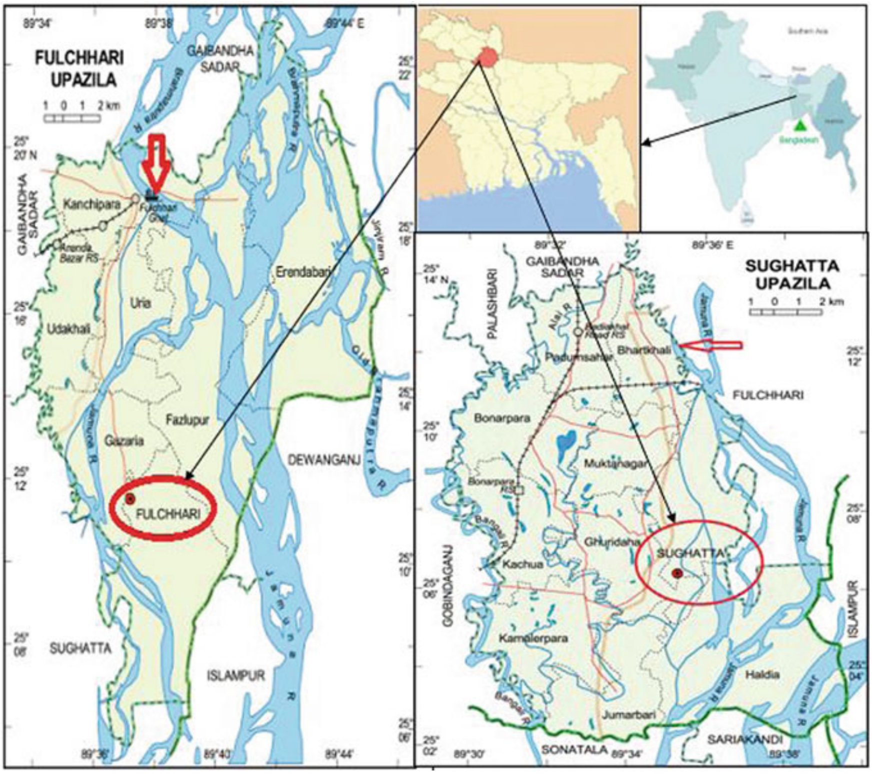

Fig. 14.1 Map of the study area location. *Source* https://www.thebangladesh.net/rangpur-division

schedules with close and open-ended questions were administered in collecting relevant data from the study area. A total of 319 respondents, who were the head of their households, were selected for the interview through a process of random sampling. Quantitative data have been analyzed by using statistical tools and qualitative data interpreted through textual and document analyses. A five-point Likert scale has been used to analyze data on the attitude, experience, and satisfaction of the flood-affected people.

Disaster Management in Bangladesh: NGO Setting and Perspectives

NGO activities in Bangladesh can be traced back to the British colonial period. Their activities in those days were largely limited to philanthropic work such as establishing schools, hospitals and orphanages. In the development sector, NGO activities were noticed following the massive cyclone of 1970 in which some 500,000 people died in coastal districts. However, a proliferation of NGOs was noticed after the independence of Bangladesh in 1971. At present, approximately 22,000 NGOs (nearly 1400 registered with the NGO Bureau, including 150 foreign NGOs) are actively working in Bangladesh (Hasnain and Jasimuddin 2013; Matin and Taher 2001).

In the 1980s, NGO activities and operations grew further due to weaknesses of the government systems coupled with support from donor agencies for improved delivery and services (World Bank 1996). Various agencies of Government of Bangladesh, international donors, and the non-government organizations have experimented with different models and approaches of institution-building for rural and local level development (Aminuzzaman 2000). These organizations were also actively involved in providing their efforts with emergency response, recovery and rehabilitation activities to manage disasters over the periods. Along with the international organizations, some local and national non-governmental organizations were especially involved with relief and rehabilitation activities. Besides, some of them such as Grameen Bank, Proshika, BRAC and ASA, also operate micro-credit programs acting as a social safety net during disasters (Hossain 2012).

In Bangladesh, both Government Organizations (GOs) and NGOs work in a collaborative manner with disaster. The government, NGOs, and local community-based organizations (CBOs) work together to minimizing the impact of calamity through preparedness, mitigation measures as well as coping in the aftermath of any crisis or disaster. A review of the past collaborations indicates three major types of arrangements: (a) Subcontract; (b) Joint implementation; and (c) Government as a financier of NGO projects (World Bank 1996). The most common collaboration is the sub-contracting arrangement where Government agencies enter into contracts with NGOs. Joint implementation on a partnership arrangement, where NGOs are involved either as co-financier or joint executing agency with the Government, is least practiced. In the area of micro-credit, there is an emerging trend for the Government to finance NGOs' credit operations.

Thus, the NGOs are focused on playing key roles in the immediate aftermath of disasters by extending assistance in emergency response, rescue and first aid, sanitation and hygiene, damage assessment and assistance to external agencies bringing relief materials. During the post-disaster phase, the NGOs play important roles by providing technical and material support for safe construction, the revival of educational institutions, and restoration of means of livelihood and assist the government in monitoring the pace of implementation for various reconstruction and recovery programs. Based on different studies and documents, it is found that the role of NGOs in disaster management in Bangladesh is significant (Sarkar 2009). NGOs are also increasingly involved in disaster preventive measures such as disaster risk reduction.

The Char Villages: Socioeconomic Profiles of the Households

Apart from the unique geographical features of the flood-prone chars, the socioeconomic situations of the char inhabitants are precarious that exhibit clearly their everyday vulnerability. A brief summary of the socioeconomic profiles of the respondents is presented below.

Demographic Characteristics

Of the 319 respondents (i.e., heads of household), 95% are males and only 5% are females. Female respondents represent female-headed households (mostly widows); in limited cases, female respondents provided household-level data in the absence of their husbands. Of the total sampled households, 248 (78%) households have nuclear families, and the remaining 71 households (22%) live in joint families.

Education

In the flood-prone area, literacy rates are very low compared to the rest of the country. Only 33% of the respondents were found literate compared to national literacy rate of 74% (Tribune 2019). This is largely due to lack of access to school in chars. The priority in the chars is everyday survival for a large number of people, and therefore, attending school is secondary as everyone in the family must work in agriculture, fishing, cattle herding or boat plying to support and sustain the family.

Land Ownership, Occupation and Income

Over half of the respondents (55%) reported agriculture as the main occupation, followed by wage labor (20%), fishing (12%), small business (7%) and other (3%) economic activities. Close to 50% of the households have less than an acre of land and 22% have no agricultural land. The ownership of land varies from one season to another due to periodic erosion and loss of land in the char areas. In many instances, ownership of land in chars is disputed (see Chap. 24).

Only 8 (3%) respondents reported salaried job a primary source of income. According to the data collected, there are varying range of incomes reported by heads of household—for example, 24% of respondents have cash income of less than Taka 3000 a month; nearly 19% reported up to Taka 9000 a month while 10% belong to income bracket of Taka 9001 to Taka 12,000 and about 7% have over Taka 12,000 as monthly income. It was further found that only 15% of the households have some savings; the rest live on a day-to-day basis. Most households rely on the meager but multiple sources of income. The precarious living is largely defined by flood and erosion disasters (Khan and Nahar 2014).

Quality of Housing and Availability of Other Amenities

In char villages, the quality of housing is generally poor, made largely of mixed materials such as wood, bamboo, and CI sheet that can easily be dismantled and

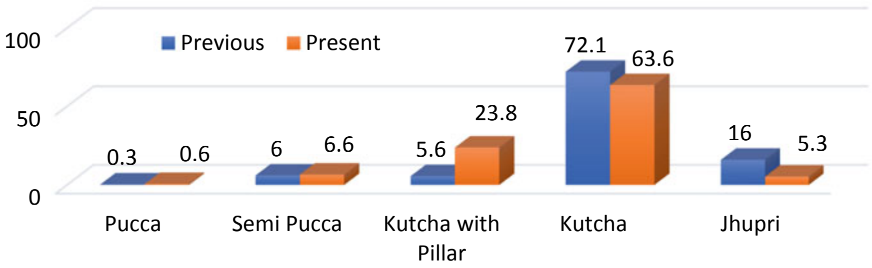

Fig. 14.2 Comparison between the pre- and post-flood housing conditions. *Source* Field Survey June–September 2018, December 2018–April 2019

folded quickly in the event of flooding and erosion threats. This in large measure is an adaptive strategy to endemic flooding and erosion environment in the char areas (Haque and Zaman 1989). Figure 14.2 lists the quality of housing in pre and post 2017 flood in the two char villages. Nearly three-fourths of the respondents had *kutcha* houses prior to 2017 flood. The *pucca* and semi *pucca* houses are relatively stronger and safer. *Jhupris* are made of fragile materials such as bamboos and straws. A large number of households (72%) had kutcha houses prior to the 2017 flood; the numbers decreased by more than ten percent to 63.6% in post-flood period due to assistance, including improved materials, provided by NGOs for re-housing and reconstruction.

In the study villages, 94% have access to tube wells for drinking water; about 6% of households have filtered water, thanks to the Pond Sand Filter (PSF) Project financed by Shouhardo, an NGO and implemented by SKS. Nearly 89% reported to have access to sanitary latrines, mostly *kutcha* (with slabs and a fence around it) and used by women in the households. Male members still typically use open fields for defecation while they are out to work and fishing.

For medical help, people depend on untrained village doctors. Many char people also rely on traditional herbal treatments. Some NGOs have mobile clinics that the study villages do not have electricity connection; however, most are found to use solar energy provided by NGOs on relatively easy terms and conditions.

Post-Flood Rehabilitation: Measures Taken by NGOs

For post-flood rehabilitation and recovery, government and non-government organizations are found to take measures to rebuild infrastructures such as rural roads in affected areas. For major flood disasters, rehabilitation takes years. However, rebuilding economic strength of the affected people may take an even longer time. Also, post-flood recovery operations require significant coordination and planning among concerned government and non-government agencies to get the desired result. Although various agencies provided different kinds of assistance following the devastating flood of 2017, many of the affected households failed to recover adequately from their losses.

Table 14.1 Amount of financial help as loan from NGOs

Amount[2] (Tk)	Frequency	Percent out of total respondent	Percent out of loan receiver
10,000.00	17	5.3	13.1
15,000.00	12	3.8	9.2
20,000.00	37	11.6	28.5
30,000.00	20	6.3	15.4
45,000.00	9	2.8	6.9
50,000.00	9	2.8	6.9
60,000.00	8	2.5	6.2
70,000.00	7	2.2	5.4
80,000.00	6	1.9	4.6
90,000.00	3	0.9	2.3
100,000.00	1	0.3	0.8
120,000.00	1	0.3	0.8
Total loan recipients	130	40.8	100.0
Did not receive any loan	189	59.2	
Grand Total	319	100.0	

Minimum = 10,000.00, Maximum = 120,000.00, Mean = 34,500, Std. Deviation = 23,760.42
Source: Field Survey 2018–19

Financial Help and Assistance

Financial help is understandably important for overall rehabilitation of the flood-affected people. Along with government cash assistance, some NGOs were also found to have provided financial assistance as donations during emergency periods. Apart from this, government and non-government organizations provided loans for various purposes in post-disaster recovery. These include loans meant for income-generating activities (IGA). Table 14.1 lists the range and amount of loan received from NGOs. In addition, food and non-food items were provided to the affected families.

As evident from Table 14.1, nearly 41% of the sampled households received post-flood financial help in the form of loans from government and non-government organizations. This also means that more than half of the households interviewed did not receive any loan. It was not ascertained whether they did apply for loan or simply did not want to take loan from NGOs. The amount of loan varied from Take 10,000 to Taka 120,000. Figure 14.3 provides modalities for loan repayments such as weekly, fortnightly, monthly and so on. The weekly repayment seems more common (47% of the loan recipients). Those receiving loans from NGOs reported satisfaction regarding the process; however, the interest rates charged were considered to be too high.

[2] Bangladeshi Taka, approximately Tk. 84 = US$1 in 2017–18 period.

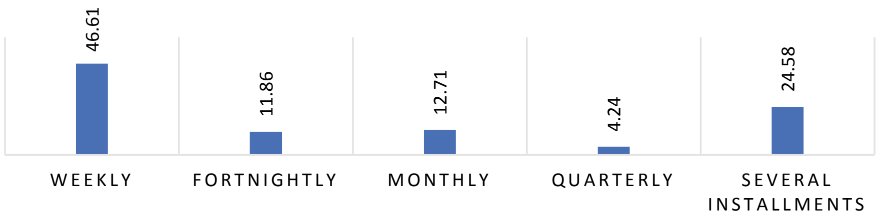

Fig. 14.3 Loan repayments modality and schedule. *Source* Field Survey June–September 2018, December 2018–April 2019

Relief and Infrastructure Rehabilitation

It was reported that NGOs provided relief during the flood, which included food and non-food items like clothing such as *saris* for women, and *lungi* for men, sanitary pads, mosquito nets, kitchen sets, bottled water and CI sheet. Besides, NGOs helped in removing junk and debris left by floods, repaired earthen roads, tube wells, and set up new latrines for the villagers. SKS repaired 3 km earthen road and 7 tube wells, raised 25 house plinths, removed debris with the help of local people under the CLP project, and provided medical support to countless number of the affected people. In the same area, GUK repaired 2 km rural earthen road and 5 tube wells, raised 22 house plinths, cleaned 3 ponds, excavated 2 ponds, and provided medical support to 68 affected people. ASA provided medical facilities to 33 affected people, and BRAC also provided medical support in post-flood period.

Housing Reconstruction

As mentioned above, most houses in the study chars are *kutcha*; the materials used are not strong enough to withstand forces of the floodwater. As a result, 297 (93%) of the 319 households either lost their houses or their houses were severely damaged due to the devastating flood of 2017 flood. Of them, 97 (33%) households received post-flood NGO support in supplies of construction materials, cash, and; in some cases, even complete houses. Assistance provided for reconstruction was based on post-flood assessment and recovery surveys by various NGOs working in the area. Among the NGOs, SKS constructed houses at Kalur para for the severely affected poor people with the help of OXFAM and USAID. Figure 14.4 provides data regarding the quality of the newly constructed houses with NGO support. Over 70% of the response ranked the quality of construction from moderate to very good.

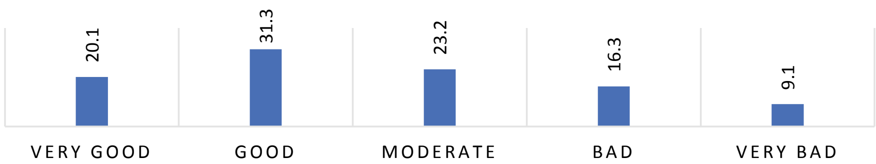

Fig. 14.4 Quality of housing materials provided by NGOs. *Source* Field Survey June–September, 2018, December 2018–April, 2019

Table 14.2 Types of assistance received for agricultural rehabilitation

Types of help	Frequency	Percentage
Financial help as loan	118	44.2
Seed/plant	70	26.2
Equipment	40	14.9
Total recipient	228	85.4
No of HHs w/o help	39	14.6
Grant Total	267	100.0

Source Field Survey June–September, 2018, December 2018–April, 2019

Assistance for Crop Production and Agricultural Development

According to the survey, 84% of respondents lost their crops because of the devastating 2017 flood. Major crop lost was paddy, which was almost ready for harvest. Other crop losses include wheat, corn, and jute. Some banana gardens were extensively damaged. Table 14.2 lists the type of assistance received by the respondents for post-flood agriculture rehabilitation.

The beneficiaries also received advisory and technical support from NGOs for home gardening in ensuring nutrition and reducing malnutrition. Home gardening for vegetables included, among others, cultivation of eggplant, bottle gourd, spinach, carrot, radish, tomato, beetroot, spinach, okra, red pumpkin, ash gourd, chilly, bitter gourd, and papaya.

Concluding Observations

Floods are a complex phenomenon with physical, social and economic dimensions, requiring massive post-flood rehabilitation. The char villagers are more vulnerable to floods due to their pre-existing precarious socioeconomic conditions. Among the various needs in post-flood rehabilitation, housing and agricultural recovery are more critical. In the study villages, housing reconstruction was an important NGO post-flood rehabilitation activity. The 2017 flood led to inundation of a large area in the northwest, particularly Gaibandha District, damaging nearly every house in the two study char villages. Since the 1988 flood, the NGOs, with their years of post-disaster rehabilitation experience, have increased their attention to housing reconstruction, followed by agricultural rehabilitation (Borton and Beck 1992). NGO relief and rehabilitation work, including construction materials, cash grants and/or loan, have helped the affected families rebuild and/or repair their houses. However, the NGO led post-flood rehabilitation houses to poor families on a loan basis undermine the essence of development program. There should be a housing policy for post-disaster rehabilitation for the char people as the needs are greater in char areas than the NGOs can support with their limited and short-term programs. Any future char development strategy should consider such a housing policy for the char people.

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Chapter 15
Flood Proofing to Reduce the Vulnerability of Char Communities: Experiences and Future Directions

Ian Tod and Monzu Morshed

Abstract Char dwellers live in a harsh environment dominated by the double hazards of floods and erosion, as well as high tides and cyclones in the case of coastal chars. Historically, households have developed their own strategies to overcome these hazards as they receive little government support but their strategies are often ineffective for extreme events when households can suffer substantial losses and dislocation to their lives. Flood proofing comprises minor structural or a range of non-structural measures to mitigate the impacts of the major hazards of floods, erosion, high tides and cyclones. In this chapter, the development and effectiveness of flood proofing measures in riverine and coastal chars are discussed before describing a range of flood proofing measures that have been implemented on some of these chars. Finally, a discussion is undertaken on the potential for further application of flood proofing measures. The main finding is that flood proofing measures are economically sound investments and effective in reducing the vulnerability of char households.

Keywords Flood proofing · Vulnerability · Adjustments · Risk reduction · Case studies · Bangladesh

Introduction

The land in the active flood plains of the major rivers in Bangladesh is transitory because of the erosion-accretion processes of the braided and meandering river channels (see Chaps. 8 and 9). The land in the active floodplain is commonly known as charland although a char in Bangladesh is, in its strict sense, a mid-channel island formed by accretion (Elahi et al. 1991) To reflect the range of lands within the active floodplain, the definition of charland was expanded to include all land between existing or potential flood protection embankments and subject to the

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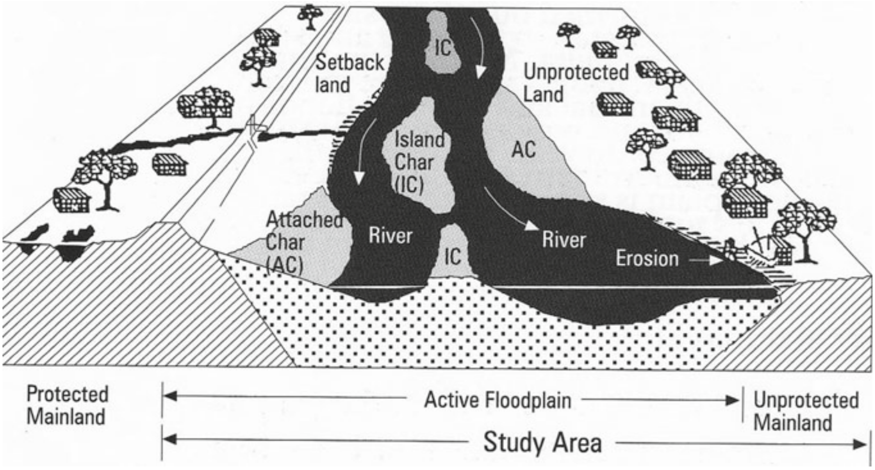

Fig. 15.1 Charland Classification. *Source* FAP 23 (1993)

riverine processes, by including islands chars surrounded by river channels, attached chars with a river channel on one side and connected to the mainland on the other, setback mainland located between the embankment and river channels and unprotected mainland located within the river channels, as shown in Fig. 16.1 (FAP 16/19 1994a). In Bangladesh, the charland of the three main rivers—the Brahmaputra-Jamuna, Ganges-Padma and Meghna—cover some 8450 km^2 with an estimated population of 6 million in 100 upazilas and 32 districts (CCNC 2015) (Fig. 15.1).

The lives of communities living in the harsh environment of the charland are dominated by the double hazards of floods and erosion, as well as cyclones and associated storm surges in the case of coastal chars. Drought and cold weather are additional hazards affecting the charland. Historically, disasters caused by these hazards are a major contributor to entrapping char households in poverty and food insecurity, because they do not have the resources and any effective risk management mechanisms in place to absorb the resulting shocks and stresses. The char households receive little government support, so have developed their own strategies to survive in this challenging terrain, but their strategies are often ineffective for major flood or erosion events, during which households often suffer substantial human and physical losses and disruption to their lives. Development gains are not sustainable without addressing the disaster risks caused by flood and erosion.

Until 1990s, the charland and their hazards were largely ignored by public policy, resulting in these areas being poorly served by public infrastructure and services. Difficult access and unstable, changing land resources contributed to the lack of development and even NGOs were reluctant to work with char people because of these challenges. The neglect of riverine chars changed when the Flood Action Plan (FAP) commissioned studies to analyze erosion and accretion patterns in the chars and to prepare an inventory of population and resources of all char communities (FAP 16/19 1994a). In addition, the Charland Flood Proofing Study assessed the impacts of floods on riverine char households and identified feasible measures for households to take in mitigating the impact of floods (FAP 16/19 1994b). By coincidence, during the same period, the neglect of the flood proofing needs of coastal chars received great attention following the devastating cyclone in 1991.

The data and analysis in these FAP and other studies led to better understanding of char communities by providing social and economic information on how households managed and were impacted by floods. The studies led to government, donors and non-government organizations taking a more active interest in addressing flooding and related problems of char households. In riverine chars, the collective interest resulted in several large livelihood and food security programs implementing flood proofing measures, including SHOUHARDO, funded by USAID and implemented by CARE and its partner organizations and the Chars Livelihoods Programme (CLP), funded by the government, DFID and AUSAID and implemented by Maxwell Stamp and its partner organizations (see Chap. 20). Both these programs linked flood proofing to improving livelihoods and food security. By contrast, in coastal chars the government and many donors funded flood proofing activities focused primarily on saving lives during storm surges.

Addressing the erosion hazard can be more challenging. The power exerted by changing river channels, combined with the friable nature of char soils, means that when river erosion occurs, the land on which households and communities base their lives and livelihoods disappears completely, leaving behind only a watery expanse. The erosion of charland is compounded by the trend of the major river channels to widen and erode their banks, thereby bringing households that were once on firm land into the unstable char environment. Charland is subject to erosion throughout the year but the rate of erosion tends to increase significantly during floods as water levels rise and also when water levels decline.

This chapter assesses the impact of floods and erosion on char communities before outlining the development of flood proofing in the chars, with a description of specific flood proofing measures that assist households to live with floods in the char environments. Finally, potential additional flood proofing measures are identified and discussed before presenting the conclusions. The material presented in the chapter is based primarily on over two decades of experience of the authors in working with flood proofing in both riverine and coastal chars. The information and discussion primarily comes from their own analysis, supplemented by the results from other programs and research on flood proofing activities in the chars.

Impact of Floods on Char Communities

The characteristics of floods are very different in riverine and coastal environments. Riverine floods tend to happen over weeks or months with water levels rising about 0.5–1 m per day. On the lower ground, the duration of floods tends to be for months, while peak flood levels affecting homesteads on the higher ground can last for days if not weeks. Floodwaters rise relatively slowly, which usually allows people to move their possessions onto higher ground within the char or onto boats to be transported to nearby flood shelters or the mainland. Many major floods from 1950s through to 2014 were very destructive, each with a significant impact on lives and livelihoods.

Major riverine floods come with the additional threats of erosion and sand blanketing of charland that result in the landform being dynamic and frequently changing. Char households need to be vigilant and ready to counter the threat of their homesteads and land being lost to erosion. In addition, major rivers like the Jamuna, the Ganges and the Padma are widening and have gradually destroyed around 1590 sq km of floodplains making 1.6 million people homeless since 1973 (CEGIS 2009).

The consequences of major floods on riverine char communities can be devastating. Negative impacts include loss of homestead structures and household belongings, loss of agricultural crops and homestead vegetable gardens and loss of livelihood opportunities, all of which can lead to distress sale of major assets such as livestock, poultry and building materials at reduced prices. Furthermore the need for cash to pay for labor to dismantle buildings and rental boats to take their family and possessions to refuge on higher ground can result in households having to sell their labor in advance to generate cash. Positive impacts include the deposition of new chars as water recedes, although the ownership of the newly formed land is often disputed.

The impact of floods on the char households is illustrated by the major flood of 1988, when over 90% of houses in riverine chars were inundated. The average depth of water inside houses was about 1 m and the average within-house flood duration was 2 weeks. Following traditional practices, most flooded households built raised platforms (*macha*) about 1 m above floor level inside their houses to provide a living space above flood levels. When the platforms flooded, households had no option but to evacuate to higher ground although one family member often stayed behind to ensure the security of the abandoned house. By contrast, the 1991 flood was slightly above average and only 30% of houses were flooded to an average depth of 0.28 m with houses inundated for 3–5 days. Erosion of homesteads and major floods are correlated and about 20% of households had to leave their homestead permanently in 1988 because of erosion (Thompson and Tod 1998).

Even with improvements in the socioeconomic wellbeing of many Bangladeshi households during the last twenty years, char households still face major problems due to floods. During August 2014 there were significant floods originating from the major Northern rivers like the Brahmaputra/Jamuna, Teesta and Dharla, resulting in major damages to chars and adjacent mainland in the districts of Kurigram, Bogra, Jamalpur and Pabna. The floods affected 178,575 households living in 780 villages, and 52,986 ha of crops (mainly *aman* rice) were destroyed or damaged. A total of 11,955 houses were destroyed and 42,587 houses were partially damaged. In addition, the floods caused erosion of homesteads, buildings and farmland; loss of employment opportunities; loss of fisheries, disruption of transport, loss of safe sanitation; contamination of drinking water and waterlogging of fuel and fodder (Tod 2014).

In many communities the 2014 flood was disastrous as illustrated by Char Rahmatpur, located in the Brahmaputra floodplain. Water levels started to rise around the first week of August and the flood peaked around mid-August. Although villagers reported having received warnings, the date they received their first warning is uncertain. Unfortunately, by the time the warning was received, farmers had already transplanted the *aman* crop. Water levels began to recede around the end of the third week of August; and around the end of the first week of September, most households had returned to their homesteads, although some delayed their return, as their homesteads were still not usable. Most of the cropped land had emerged from the floodwaters but the *aman* crop was ruined after being submerged for at least 21 days (Tod 2014).

River erosion is a major, life-changing hazard for char households as erosion engulfs the land and everything on the land including homestead structures, trees, crops, tube wells, etc. Char communities are not able to resist river erosion due to the technical complexity and extremely high costs of protection measures (BWDB 2015), and their response is focused on moving to a safer location when threatened by erosion. In anticipation of the need to move, char households use construction materials and keep assets such as livestock that can be easily moved and rely on community support to help them move and find a new location. However, the cost of moving for a household facing erosion was found to be in the range of Tk 5000–10,000, which can wipe out savings and undermine gains in livelihoods, thereby reducing their disaster resilience (Thompson and Tod 1998). In addition, the sudden displacement of households from their land, together with physical limitations of embankment squatting and future insecurity separates many households from their traditional organizations of mutual reliance on which char households depend. For example, Zaman (1988) reported that in one village in Kazipur repeated displacement had separated 54% of displaced households from their main support group, making them more reliant on patronage support and traditional alliances.

The impact of erosion can be dramatic, as shown in the village of Mollikpara, in Maijbari Union, Kazipur (see Fig. 15.2). Over four years, the riverbank has moved about 500 m westward displacing approximately 80 households and eroding more than 50 ha of productive land. Some displaced households had to move south of the flood shelter close to others who settled there in 2010.

Similarly, in the village of Rahmatpur, Jatrapur Union, Kurigram Sadar, 119 homesteads in the north of the village and 44 homesteads in the south of the village were eroded during the period from 2010 to 2014. Between 2003 and 2013, the productive land to the south-west of the village was eroded and then accreted, while the land to the east was accreted and then partially eroded.

By far, the major flood hazard in coastal chars is from storm surges during cyclones, when casualties and damages are exacerbated by low land elevations and rapidly rising water levels in the absence of natural barriers along the coast characterized by high population densities. Water levels at the center of the cyclone can increase by 4–7 m above the tide level within a few hours, accompanied by strong currents as saline seawater rushes inland. Storm surges last up to twelve hours, although floods may persist in low-lying areas for several days due to drainage congestion. As many as 12 major tropical cyclones have hit the country since 1965, and about 40% of the total global storm surges are recorded in Bangladesh (Huque et al. 2012).

The impacts of cyclones on people's lives and livelihoods are enormous. The biggest loss has been human lives. In December 1991, for example, when a cyclone

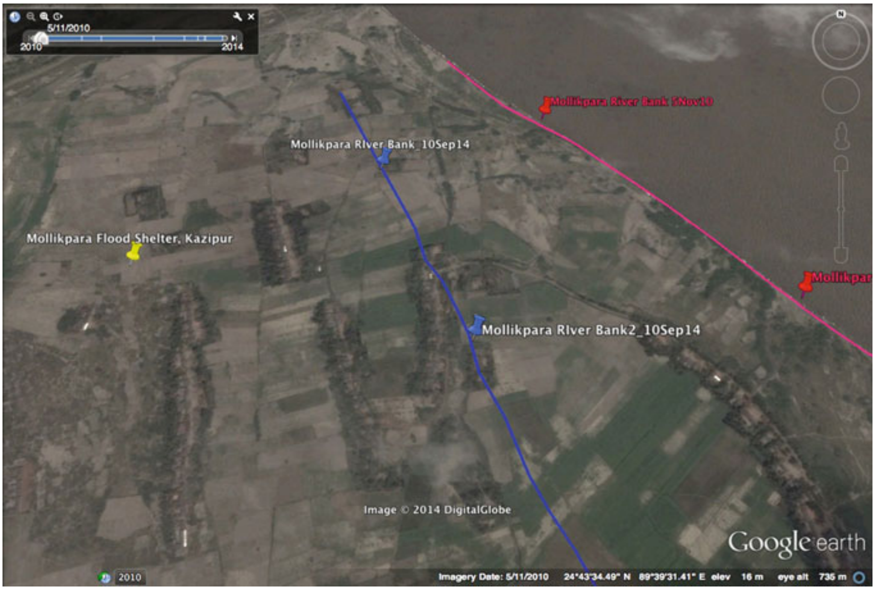

Fig. 15.2 Change in riverbank Alignment in Mollikpara, Maijbari Union, Kazipur. Ian Tod/Google earth

hit the coastal chars in south-eastern Bangladesh, a reported 138,000 lives were lost (JTWC 1992). The cyclone made landfall around the time of high tide which was already 5.5 m above normal. In addition, the cyclone produced a 6.1 m (20 ft) storm surge that inundated the coastline. The storm also brought winds of around 140 km/h (150 mph) for about 12 h. More than 20,000 died on the offshore island char of Kutubdia, where 80–90% of homes were destroyed and most livestock killed. Entire populations were wiped out on smaller island chars. Damage was widespread and severe in all sectors. The government estimated that 780,000 homes were destroyed and 9300 schools as well as 655 health centers were damaged or destroyed. In many areas ponds and other surface water used for bathing and cleaning got salinized. Roughly 247,000 tons of cereal crops and 35,000 tons of vegetables and other crops were lost. A shortage of tools, seeds and fertilizers, combined with damage to embankments and salinization of land, hampered the prospects for the upcoming rice crop. The scale of the losses severely limited the affected population's ability to return to the prior means of livelihood. However, during the past 30 years, the number of lives lost during cyclones has been greatly reduced due to investment in cyclone shelters and the development of a more effective cyclone warning system.

Flood Proofing and Flood Protection

Disaster risk reduction (DRR) is the concept and practice of reducing disaster risks through systematic efforts to analyze and manage the causal factors of disasters, including reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events (UNISDR 2009). Resilience is the ability of countries, communities and households to manage change, by maintaining or transforming living standards in the face of shocks or stresses—such as earthquakes, drought or violent conflict—without compromising their long-term prospects (DFID 2011). Shocks and stresses take many forms. Dramatic events such as floods or cyclones have a devastating, immediate impact. Stresses can take less apparent but insidious forms and often have more gradual onsets than shocks. In areas of chronic poverty, for example, an increase in food prices resulting from a disaster can trigger significant underlying vulnerability and result in crisis. Conflict within communities or with external factors can be both a shock as well as an underlying source of stress that can make communities more vulnerable to other shocks such as floods or erosion when they hit.

DRR is used to reduce the impact of a natural hazard. It requires a systematic analysis of the cause of a risk and implementing measures to reduce or remove that risk. There are five broad ways to approach reducing the risk of a disaster through preparedness, warning, mitigation, recovery and livelihoods (IFRC and RCS 2012). Flood proofing is focused on improving preparedness, warnings and mitigation. Preparedness is focused on preparing the population for potential disasters. This includes actions such as training, awareness, capacity building, contingency planning and hazard mapping. Warning involves creating systems to warn vulnerable people to prepare for an imminent disaster. Mitigation methods often involve small-scale physical measures to reduce the frequency, scale and intensity of a disaster.

Bangladesh relies on measures by both communities and individuals to mitigate the impact of floods. These measures can be divided into two: measures which protect communities by reducing the extent of flooding through the provision of structures such as embankments (that is flood protection) and measures where individual households accommodate floods by taking actions such as constructing homesteads above flood level (that is flood proofing). Moving all people out of the char is not feasible due to intense population pressure on land throughout Bangladesh.

In Bangladesh, flood proofing comprises minor structural and a range of non-structural measures to mitigate flood impacts and includes not only individual household measures such as ensuring homesteads and basic household services are above flood levels but also public or community measures such as community flood or cyclone shelters and warning systems, and measures to reduce the economic vulnerability of households to floods (FAP 23 1993).

Flood Proofing Measures in Riverine Chars

Assessments of both flood and erosion risks are required to design flood proofing measures in the riverine island or attached chars. Flood risk assessment is required to ensure that normal household activities can continue during and after a flood and flood proofing measures are often based on building facilities such as homesteads, water pumps and latrines above the highest locally recorded flood level plus a freeboard of 0.5–1 m. Erosion risk assessment is required to ensure that a flood proofing measure will function as designed and not be lost to erosion within a few years. Technical tools are not available to reliably predict river erosion at specific locations, and assessment has to be based on local trends in erosion and recent past history of erosion. All measures should be consistent with the preferences of charland people. Several successful measures are described below.

Homestead Raising

Flood proofing homesteads is achieved by raising the level of earthen homestead mounds to above maximum flood level (see Fig. 15.3). Typically, char homesteads are comprised of one or more structures around a courtyard. Many domestic activities take place in the courtyard. Benefits of creating flood proofed homesteads include

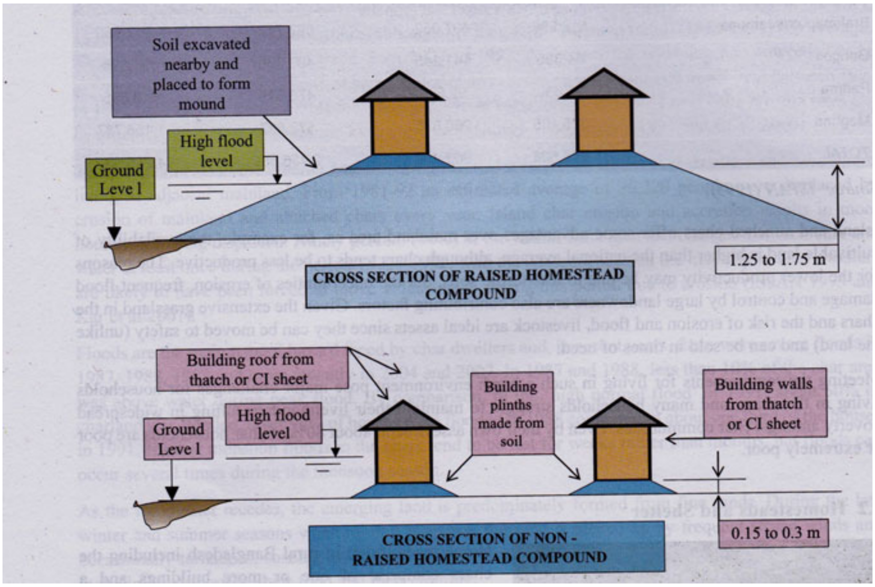

Fig. 15.3 Layout of raised homestead. *Source* Care Bangladesh 2008

reliable dry space for domestic activities during floods, reduction in diarrhea and skin diseases, more scope for gardening, drier conditions for livestock resulting in fewer distress sales during floods, removing the need and costs of evacuation, reduction in maintenance costs of homestead structure, and increased confidence in dealing with floods. Overall, homestead raising greatly reduces a household's vulnerability and improves their livelihood resilience.

Homestead raising is referred to also as plinth raising and requires the homestead structures to be dismantled before nearby soil is excavated and placed on the homestead area to form a mound. The level of the mound is raised to the desired height, usually 0.5–1.0 m above the highest local flood level. The structures are then re-assembled. Depending on the homestead area and height, raising homesteads to above extreme flood levels costs around Tk 10,000 to Tk 20,000, a significant investment for poor households. An additional benefit of subsidizing homestead raising is that households can carry out the work themselves, which provides them with income especially during the *monga* season, when other employment opportunities are rare.

A 1998 study analyzed the economic feasibility of homestead raising and, based on flood damage data collected from one village in Kurigram, determined that the economic viability depends entirely on the probability of erosion. If a homestead has to be relocated and the homestead raised every two years then it is not viable, but if the homestead is only lost every four years the homestead raising is a sound investment with an internal rate of return of 39% (Thompson and Tod 1998). Kenward et al. (2012) undertook a study to assess the performance of raised homesteads funded by CLP during the 2012 flood and found that 65% were fully intact, 29% partially eroded and only 8% submerged. The plinths were found not only to have protected household members but also cattle, food and fodder reserves and even to have provided shelter for non-core participant neighbors, creating "a social and communal good".

Homestead raising provides a flood-free environment but, in riverine charland, there remains an ever-present threat of erosion. Overall, CLP found that 17% of households with raised homesteads constructed in Phase I (between 4 and 10 years prior to the survey) lost their raised homestead to erosion. But it should be noted that CLP focused their activities on mature chars or detached mainland avoiding new and emerging chars where erosion risk may have been greater (Kenward and Islam 2011). With a high risk of losing their raised homestead to erosion, very few households make this investment themselves. Unfortunately, the households who lost their raised homesteads to erosion were not tracked to determine whether they were able to sustain the benefits of homestead raising and other program support.

Riverine Multipurpose Flood Shelters

Flood shelters are provided in riverine areas as a place of refuge for households forced to evacuate their homesteads during extreme floods. Flood shelters are comprised of a mound of soil raised above peak flood level with several buildings for sheltering evacuees and other facilities such as tube wells for water supply and latrines. Raising the mound is not expensive, up to 83% of the total cost being accounted for by the building and associated facilities. There is an overlap with potential benefits from individual homestead raising, but the main additional benefits of a shelter are saving livestock (preventing loss and moving costs) and safeguarding fodder supplies. However, these potential benefits may appear insufficient to make the shelter economically viable when building costs are considered. Nevertheless, shelters are viewed as more secure during disasters and can withstand their onslaught over time.

However, if the buildings and facilities have multiple uses and benefits to the community in normal times, for example, as a school, clinic or community center, so that its costs are covered separately, then the extra cost of raising the mound becomes viable, provided the site was secure from erosion for at least four years giving a rate of return of 34%. It is important that any building is designed to take account of the erosion hazard and a plan for moving the building and related facilities should be developed by communities, since the investment could otherwise be lost (Thompson and Tod 1998). Multipurpose flood shelters are often considered as priority flood proofing measures by char households and are used extensively when required. For example, in Mollikpara, Kazipur, Sirajganj, around 35 households took refuge in the recently completed school-cum-flood shelter during the 2014 flood.

Riverine Flood Warning Systems

The three elements of a Flood Warning System are forecasting, dissemination and response. Since 1972, BWDB's Flood Forecasting and Warning Centre (FFWC) has been developing a reliable system for preparing flood forecasts and warnings. FFWC's traditional three-day forecast has been extended successfully to five days, and the RIMES (Regional Integrated Multi-Hazard Early Warning System) 10-day forecasts are becoming more reliable (RIMES 2014). For example, at Kazipur on the Jamuna River, the RIMES model predicted flood that crossed the danger level on August 19^{th} eight days in advance. Unfortunately by mid-August, farmers had planted the *aman* crop, and the eight-day warning was of little use as they had already made the investment. However, the eight days did allow time for the message to be disseminated widely and for households to prepare in different ways for the flood (Tod 2014).

The dissemination and response elements of the flood warning system in riverine chars are less developed. Dissemination has two elements: transmitting the warning to end-users and ensuring the content of the warning is understood. The dissemination and response protocol of the flood warning system in riverine areas has been developed by FFWC, the Ministry of Disaster Management and Relief (MoDMR) and local government institutions. The transmission of warnings is now much easier than a decade ago due to the proliferation of mobile phones and the Internet access throughout much of the country. RIMES evaluated the dissemination of its forecasts during the normal 2013 monsoon (RIMES 2013) and found that forecasts would be more useful if disseminated in Bangla, forecasts should be sent to all potential users including prominent persons like teachers,[1] UP members, and religious leaders, and extensive training should be provided to show recipients how the forecasts can be utilized. Another assessment (SHOUHARDO II undated) found that, although people in the community used the forecasts for various purposes, including assessing the flood threat to their household and livestock, making farming decisions on seedbed preparation, planting, and harvesting and stocking food, there were gaps in the early warning system. UPDMC (Upazila Parishad Disaster Management Committee) members were not able to understand and interpret the forecast, which prevented them from disseminating the forecast, fearing people's loss of confidence in them. The key finding from both assessments is that more work is required on the second element of dissemination; ensuring that recipients understand the forecasts they receive.

Hand Tubewells

Although there has been a proliferation of tubewells throughout Bangladesh, many char households face challenges accessing safe drinking water, especially during floods and droughts (TANGO 2013 and CARE-BD 2014). Tubewells can be flood proofed by ensuring the operating mechanism and discharge outlet are above peak flood level and the tubewell has a protective platform to stop floodwater from entering the borehole.

Tubewells located on the courtyard of raised homesteads provide a proven option. During the 2012 flood, 84% of tubewells on raised homesteads remained intact. Even though a small percentage of core participants saw their tubewells submerged, all had access to a tubewell, either their own, or a shared, or nearby tubewell. However, only 33% of households had access to clean water and this small percentage was attributed to the large amount of tubewells with inadequate or broken platforms. (Barret et al. 2014).

Latrines

Access to safe sanitation is a major need during and after floods in the chars, especially for women (CARE-BD 2014). Many households still practice open defecation, which becomes difficult when the landscape is flooded. The government and many NGOs

[1] Teachers are the only government staff based in villages. Other government staff, for example, from the Departments of Health or Agriculture, are based at union level and visit individual villages periodically. Hence, they are not appropriate as focal points for disseminating flood warnings to communities.

have promoted pit latrines comprising 1–2 m deep pit lined with bamboo or concrete rings and with a concrete slab with a water sealed u-tube on top; but even basic pit latrines are unusable during floods and liable to collapse. Flood proofing options include constructing a latrine on raised homestead mounds or raising the level of the latrine platform by adding additional concrete rings. One survey after the 2012 flood found that 68 percent of low-cost latrines constructed on raised plinths were usable during the flood while 15 percent were eroded and 17% submerged. As the flood receded, most latrines remained intact, some were weakened but still usable (Kenward et al. 2012).

Adjustment to Crop Patterns and Calendars

In charland, there is scope to identify and introduce improved rice varieties that can tolerate flooding for a period of time, but it is still essential that the characteristics of the flood are identified and reliable flood warnings are available to ensure that improved varieties can be grown successfully. For example, rice varieties BD *dhan* 51 and 52 can be inundated for up to 14 days (and still be productive) and farmers in the northern chars were encouraged to grow these varieties. Unfortunately, the 2014 flood immersed paddy fields for as many as 21 days, and even the flood tolerant varieties were destroyed. During discussions, farmers said they were discouraged after switching to flood tolerant varieties and then losing the crop to floods (Tod 2014).

Flood Proofing Activities in Coastal Chars

Similar to riverine chars, assessment of both flood and erosion risks are required to design flood proofing measures in the coastal chars, but there is an additional need to assess the risks associated with cyclones, namely high winds and tidal surges. In coastal chars, disruptive flooding usually occurs during seasonally high tides but the flood proofing measures are similar to riverine chars in that the focus is on ensuring that normal household activities can continue throughout a flood. Erosion can also be significant on coastal chars and there is a need to ensure that flood proofing measures are not lost to erosion within a short period of time. However, the major risk in coastal chars comes from the high winds and tidal surges of cyclones, and the focus of flood proofing activities has been to avoid the loss of life during and after cyclones. Only the few brick-built houses are tall enough to be above water levels during storm surges and able to withstand the surging waters and high winds. In char areas, the priority flood proofing actions taken so far have been to provide community cyclone shelters in order to save lives during storm surges and to provide cyclone warnings to allow people time to evacuate to cyclone shelters or higher ground inland.

Multipurpose Cyclone Shelters

Cyclone shelters are multi-storeyed buildings constructed from durable materials such as concrete or brick. Shelters are raised above ground level and are designed so that flooding from the surge passes underneath the building (see Fig. 15.4).

A typical cyclone shelters can accommodate 500–2500 people and serve as an evacuation center for several hours for the duration of the storm surge. The number of floors, rooms and facilities vary and many shelters are also being used as schools or clinics between cyclones. In April 1991, when the devastating cyclone struck the Chittagong coast, there were some 572 shelters in the coastal zone.

As a response to the high death toll, mainly on the coastal chars, the government was supported by many donors to prioritize construction of additional cyclone shelters. By 2007, there were 3976 shelters. However, many shelters are now over 20 years old and an estimated 1576 are no longer usable due to poor construction, poor management and/or maintenance (Miyaji et al 2017). Renovation of cyclone shelters often involve minor tasks such as replacement of doors and windows, re-plastering and painting and partial replacement of sections of roof and floor slabs. On the positive side, during the alert for Cyclone Mahasen in May 2013, significant numbers of households moved to cyclone shelters in anticipation of the storm (BBC 2013). According to the union council, the entire population of Julia Palang Union,

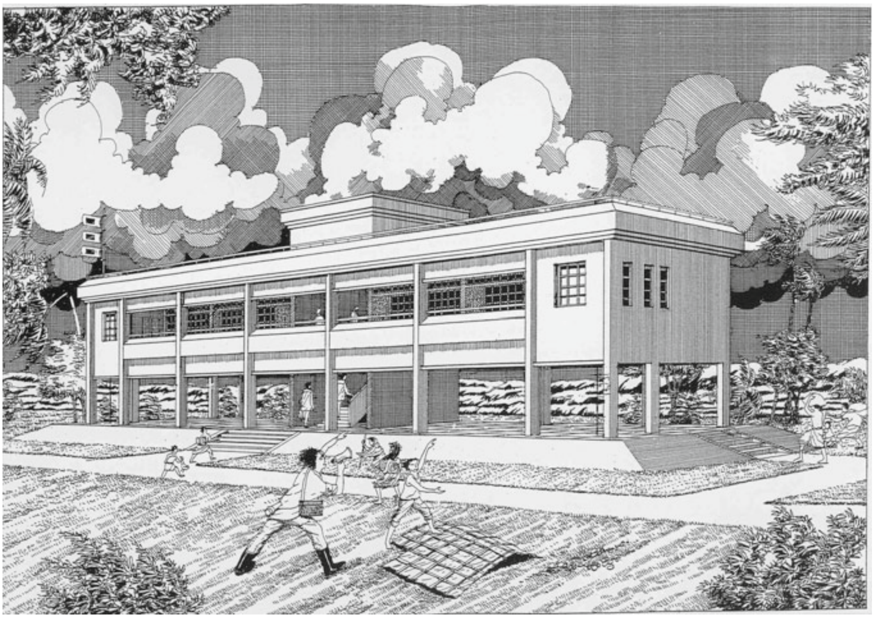

Fig. 15.4 Design and drawing of a multipurpose cyclone shelter. *Source* CARE Bangladesh 2010

about 55,000 people, were able to shelter safely in anticipation of cyclone. People started moving to safe places about 2 days before the cyclone was due to strike.

Cyclone Warning System

The cyclone warning system in coastal areas have been developed by the Bangladesh Meteorological Department and issues cyclone warnings based on predictions made by its specialist unit the Storm Warning Centre (SWC). For dissemination of warnings BMD uses the cyclone warning network developed in 1973 under the Cyclone Preparedness Programme (CPP), a joint venture between the government and the Bangladesh Red Crescent Society (BRCS). Local volunteers disseminate warning signals sent from National Headquarters to affected unions. Volunteers also assist disaster-affected people in shifting to safe shelter, undertake search and rescue operations and provide first aid to the injured (Ferdous 2017). The cyclone warning system have been a major factor in reducing the number of people killed during cyclones.

The dissemination of cyclone warnings is well established in coastal areas, but even though the warnings reached a large percentage of the population during Cyclones Sidr in 2007 and Mahasen in 2013, many residents who knew the potential consequences of non-evacuation still did not take adequate protective measures. Reasons for non-evacuation included mistrust in the warning messages, not understanding the instructions conveyed, insufficient number of cyclone shelters and poor road conditions. (Roy and Kovordanyi 2015).

The cyclone warning system used by BMD were inherited from the Indian Meteorological Department (IMD) and developed during the time of British rule. The system includes two types of signals used for maritime or seaports and inland river ports, respectively. For maritime ports eleven individual signals are used in different stages of a disaster and for inland ports four separate signals are used. Evidence shows that these two types of signals for the same cyclone are confusing for local people. Previous attempts to improve the warning system have not been successful, in part because they were lacking information required to improve the current warnings and make them more locally understandable. However, the newly developed Cyclone Classifier Model (CCM) looks promising. Rather than changing the existing signal number, which is socially sensitive, CCM adds information on location specific wind speed, surge depth, house damage, embankment damage and provides a hazard map for the coastal region which has the additional advantage of keeping the traditional stages and administrative actions of cyclone response intact (Rashid et al 2019).

Future Directions for Flood Proofing

Housing and Shelter

Buildings for shelter are often a char household's major asset but the buildings are often of poor quality and very vulnerable to damage during floods or loss due to erosion. The buildings are constructed using locally available materials, usually bamboo, timber, thatches, various types of leaves and reeds. More recently, due to increased incomes, some households can afford to purchase more durable materials such as corrugated iron (tin) sheet. As a flood approaches and water levels rise, side panels are removed from the walls to allow water to flow freely through the building, and a raised platform or *macha* is constructed inside the building on which householders can continue to carry out their daily tasks, including sleeping. To cope with erosion, households use materials that are easily moved and construction techniques that allow rapid dismantling, although plant-based materials may be fragile when moved and unsuitable for re-use. Shelter construction usually follows non-engineered methods, with expertise passed from one generation to the next and from one construction professional to another. Tried and tested over decades, in a particular context, non-engineered housing often holds a lot of inherent wisdom. The most vulnerable char households tend to occupy low-quality buildings and after disaster struggle to rebuild a similar house. Flood proofing should focus on supporting the most vulnerable to redesign and reinforce their basic houses and make these safer and capable of resisting flood or erosion impacts. Also important is to ensure that after disaster they can find a safe, healthy and dignified housing facility for themselves.

Transport

When surveyed, char households often stated inadequate transport facilities as a constraint on efforts to reduce flood damage (Thompson and Tod 1998). In addition, poor transport links increase the cost of accessing markets and services. In riverine charland, transport requirements are categorized into two distinct seasons. In the summer and fall when river levels are high, travel is much easier and quicker as boats can move directly between charland communities and the mainland across flooded charland. By contrast, when river levels are low in winter and spring, moving between chars and the mainland is slow and time-consuming as travel can involve walking several kilometers across charland to the nearest river channel, then taking a short ferry crossing followed by walking again for potentially several kilometers across more charland. Transport by road is very limited as road embankments are scarce due to frequent flooding and erosion. A further constraint on movement within charland is that the availability of boats varies between seasons. During and after the monsoon when river levels are high there is high demand and boats are plentiful, although there are still locations where boats are scarce. In the winter and spring when river levels are low and movement requires multiple modes of transport, many boats are idle or look for business downstream. In coastal chars, access to cyclone shelters is a major transport requirement for people when there is an approaching cyclone. The use of transport in charland needs to be researched in more detail to determine how constraints can be addressed.

Land Tenure

Land tenure is a highly political and contentious issue throughout Bangladesh and factors surrounding land tenure are amplified in the chars where violence is often the ultimate arbitrator of all disputes over land (Haque and Zaman 1989; also, see Chap. 24). Furthermore, as per Lahiri-Dutt and Samanta (2013:38), "Several factors make chars difficult like the convoluted legalistic language of the land documents, the difficulty of proving ownership of char lands by its residents and acquiring such documents, continuation of rent payment for lost/eroded char, difficulty in accessing land document officials and finally establishing rights over ownership."

This opaque land tenure system discourages households from evacuating during floods, as they do not want to leave their property for fear of others taking it over in their absence. Although the Land Reform Ordinance of 1984 included provisions to protect people from eviction from their homesteads and recognized the rights of sharecroppers, there are no proper and effective policies in place for people who lose land due to river or coastal erosion or floods. Reasons for this include a shortage of land resulting in fierce competition for any available land, regional variation in land resources, bottlenecks for implementation of land reform and absence of any centralized system of information on land resources and land rights. (FAO undated). In order to flood proof char households, land administration reform is required to address failures to implement land reforms and land violence. Land governance should be a key issue in such land administration reforms that should also consider issues related to disasters and land tenure and be linked to current disaster management and response frameworks and policies. Technologies such as GIS and satellite mapping could be used for collecting and maintaining information on land resources and tenure issues and made available to local levels of administration.

Post-Disaster Relief and Insurance

In order to assist char communities to become more sustainable, different practical ways of covering the financial costs of flooding, erosion and cyclones need to be developed. Char households have few resources and when disasters strike they are dependent on the government or external resources to help their recovery. Even though government and donors spend large amounts of money in the aftermath of disasters, the funding gap is still high and the assistance may take time to mobilize.

One possibility of financing disaster relief and recovery is some form of flood or erosion insurance. In general, the provision of agriculture insurance in Bangladesh is very low (Quayyum and Clarke 2018).

Developing insurance in rural areas was tried by OXFAM and Centre for Insurance and Risk Management (CIRM) in 2012 when they launched an index-based flood insurance scheme focused on disaster preparedness that involved several private sector and meso-level institutions (Oxfam 2013). The scheme is a business interruption policy that pays out according to the depth and duration of flooding in each defined flood risk zone and covered 1661 poor and vulnerable households in 14 villages located in Sirajganj district. Oxfam paid 100% of the premiums. In 2014, floods caused significant damages to several villages covered by the scheme and met the criteria for pay out, with the result that 700 families received BDT 1,982,400 (USD 25,000) to rebuild their lives (Swiss Re Group 2013). The International Water Management Institute (IWMI) and its partners further developed index-based flood insurance with an innovative model that highlighted historic flooding patterns and showed where inundation was most likely to happen. In July 2019, heavy rains caused flooding in two pilot upazilas in Gaibandha district and the model was used to calculate that compensation due was to the value of BDT 2,617,200 (USD $30,850) and BDT 55,200 (USD $650), respectively, for damage to crops incurred during the insurance period of August to October (Amarnath 2020).

There may be scope to consider insuring raised homesteads against erosion as the loss can be verified by satellite imaging or on the ground. Insurance could assist in making the practice of raising homesteads more sustainable, as eroded households could use the pay out to construct a raised homestead at a new location.

Conclusions

Community-based flood proofing measures are economically sound investments and effective in reducing the vulnerability of char households. Beneficial flood proofing measures in riverine chars include raising homesteads above flood level, ensuring that drinking water supplies and latrines are available and usable during floods, setting up multipurpose flood shelters and flood warning systems. For coastal areas, the flood proofing measures of multipurpose cyclone shelters and cyclone warning systems have contributed significantly to reducing the loss of life during cyclones.

Some aspects of these measures need to be improved, for example, ensuring that riverine flood warnings are accessible and usable by local char communities. There is scope for developing additional flood proofing measures to improve the sustainability of char households and livelihoods, including researching more durable and affordable materials for char houses, improving the availability of transport within chars and to the mainland, improving the transparency and reducing the complexity of land tenure, and developing insurance systems to provide reliable post-disaster relief.

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Part V
Livelihood Vulnerability, Adaptation and Gender Dimension

Editors' Note

Vulnerability to disasters and adjustments are a common theme in disaster studies. Various types of vulnerabilities at the local level—physical, environmental, social, and economic—are defined mainly by social conditions and differential access to resources. The four chapters in Part V explore vulnerabilities and responses to natural hazards and disasters like flood and erosion on char livelihoods and living, including the gender dimension of these situations.

Chapter 16 by Zobaer Ahmed et al. explores char dwellers' vulnerabilities and responses to climate change and other natural disasters and the existing community based agricultural adaptations. In Chap. 17, Rahman et al. highlights the coping strategies and adaptation measures adopted by char dwellers in view of the natural hazards from a market system perspective for three common crops found in char areas—chilli, maize and jute.

Hafiza Khatun et al. brings a new dimension to the discourse on adaptation focusing on periodic out-migration and its impacts on three chars in the Padma, Jamuna and Meghna floodplains. Migration is viewed as an adaptive mechanism to reduce risk and uncertainties and to gain better sources of income toward supporting families left behind. A significant percentage of the migrants are young women, who work in garment industries, and spend most of their earnings for their families. The patterns of out-migration from char areas can be seasonal, circular, or even permanent in some cases.

The chapter by Suzanne Hanchett reviews multiple issues of concern to women living in chars—poverty, social marginalization, and low literacy rates. Problems of dowry, child marriage and other social restrictions are still prevalent in the chars. Benefits of large-scale project interventions like CLP and CDSP for social development in chars are recognized; however, such limited interventions are considered inadequate and unable to address the needs of char people at large, particularly those of the women living in chars all across the country. It is, therefore, argued that women's issues need to be put at the center of any new human development strategy for the charlands in the country.

Chapter 16
Agriculture in Riverine Chars: Vulnerabilities to Climate Change and Community-Based Adaptation

Zobaer Ahmed, Hermann Lotze-Campen, and Md. Humayun Kabir

Abstract This study explores char dwellers' vulnerabilities and responses to climate change and other natural disasters and the existing community-based agricultural adaptations. Both quantitative and qualitative data have been used from a study carried out in Raydas Bari Char in Gaibandha District. Using SENTINEL 2 and LANDSAT 8 satellite imageries, annual flood vulnerability map and drainage patterns based on topography have been produced. The historical monthly mean temperature and rainfall graphs were also produced to showcase local hazards and vulnerabilities. The study findings show that char agriculture is highly vulnerable particularly to frequent flooding, continuous erosion, and seasonal drought. The study further reveals that char farmers adopted several community-based adaptation strategies in agriculture such as introducing new disaster tolerant crop varieties, water intensive irrigation system, changing planting times, and cultivating short duration varieties. A holistic developmental approach, including enhancing access to finance, capacity building, effective community governance and targeted policies, are needed to enhance local adaptations and building resilience to reduce vulnerabilities to natural hazards in char agriculture.

Keywords Natural hazards · Vulnerability · Charland agriculture · Resilience · And community-based adaptation

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Introduction

The current trend of climate change is an important concern for many socio-economic and climate-sensitive sectors such as agriculture and food production (Amedie 2013). Agriculture is a major social and economic activity offering a broad range of ecological services. Worldwide, approximately 1.2 to 1.5 billion hectares of land is under crop production (Howden et al. 2007). Presently, the world population is estimated at around 7.7 billion, which is projected to be 9 billion by 2050 (Rahman 2016). To sustain the estimated growth in human population and per capita demand in food production, there is an urgent need for an increase in historical agricultural production, to an extent that it should ultimately double the present production (Howden et al. 2007). However, with the occurrence of climate change and global warming, accomplishing the global food security target is expected to be a major challenge (Misra 2014). Bangladesh, which is considered the epicenter for climatic impacts, will likely be hard hit by the impact of climate change globally (Kabir et al. 2016).

In Bangladesh, the climatic parameters are affected by a number of global and local dynamics (see Chap. 11). During the monsoon period, the rivers overflow and carry a significant amount of silt. A huge part of that silt is deposited in the shallow water along the floodplains and island chars. Gradually, this sedimentation forms a new land surface configuration called chars, which can take the shape of island chars. They are shaped and restructured every year through silt deposition and erosion. Chars are of two types: attached chars and island chars (Roy et al. 2015). The attached chars are linked to the mainland under normal flow. During the dry seasons, attached chars can be accessed without crossing a river channel. During the floods, many attached chars become island chars. For island chars, throughout the year, they are surrounded by water and can only be accessed from the mainland by crossing the main channel even through the dry season. Riverine chars are seen in the northern and middle part and coastal chars are in the southern part of Bangladesh. According to one source, close to 6 million people live in chars in Bangladesh (Conroy et al. 2010).

Regardless of their geographic connection to the mainland and distance from the growth centers, char dwellers are extremely poor and highly vulnerable (Conroy et al. 2010). Shortage and challenges of access to food, health, education, habitation, and empowerment serve to make it almost impossible for the poor to rise above the poverty cycle (Lahiri-Dutt and Samanta 2007). Among the different agro-ecological zones and hydrological regions of the country, the char areas are particularly vulnerable to natural disasters, such as floods, erosion, and drought, due to unstable land, the remoteness of the areas from mainland and absence of extension and support services (Alam et al. 2017). To live with the river and to make a living on the chars is not an easy task. All residents of chars must take risks to cope with persistently changing mood of the river, a process that Lahiri-Dutt and Samanta called "dancing with the river" (Lahiri-Dutt and Samanta 2013). The fragile nature of the physical environment upon which the chars are located makes them not only risky but also disaster prone to human settlement. Also, rapid climate changes are posing additional threat. However, the char people have been found to seize the minimal opportunities to build assets and livelihoods in support of their households (Islam et al. 2015).

Agriculture is the main livelihood option in char areas. Most of the char inhabitants are directly and indirectly involved in agriculture (World-Bank 2013). Char livelihood depends largely on agricultural production. Cropping system in char is quite different from the mainland because of sandy soil texture (Kabir 2006; also see Chap. 10). Only a few specific crops are grown in the char area like maize, groundnut, seasonal paddy, and some vegetables (see Chap. 17). Char farmers typically keep their lands fallow during the main cropping season: *Kharif* (May to October), because of high evaporation that makes the land almost impossible to cultivate without irrigation. Instead, the *Rabi* season (November to April) is the main cropping season in the char area, when temperatures are lower, which is best for vegetable cultivation. Therefore, char agriculture must adapt to climatic conditions and changes, more to guard against floods and erosions and impacts of climate change.

Objectives

This chapter deals with community-based climate change adaptation within the context of char agriculture and responses to risks and disaster management. Community-based climate change adaptation rests on the premise that people in local communities have the knowledge and experience to undertake locally known activities that increase resilience and reduce vulnerability to climate change impact (McNamara and Buggy 2017). The community is kept in mind and community participation constitutes the core in any risk assessment—for instance, hazard assessment, vulnerability assessment, capacity assessment, key informant interviews, and preparation and action planning (ADB 2011).

In the context of chars, community-based responses and adaptation have been a tested strategy to alleviate the severity of climate change impacts on agriculture and food production (see Chap. 17). Adaptation strategies are unlikely to be effective without an understanding of the farmers' perception of climate change. Community-based analyses have shown that adaptation strategies are community specific, meaning that one single strategy is not applicable to all areas. To implement a climate change adaptation strategy, people within communities play a vital role and thus came about the concept of community-based climate change adaptation (FAO 2016; Roy et al. 2015; Sarker et al. 2020; McNamara and Buggy 2017).

Despite the fact that climate change adaptation has been discussed for nearly 15 years, not enough research has been done focusing on community-based climate change adaptation in agriculture and vulnerability to natural hazards in char areas of Bangladesh (Alam et al. 2016; Alam et al. 2017; Islam et al. 2015; Roy et al. 2015; Sarker et al. 2020; Hagedoorn et al. 2019).

This study presents new ways of thinking and tries to find out key factors regarding community-based climate change adaptation strategies for agriculture and vulnerability to natural hazards in riverine char areas of Bangladesh.

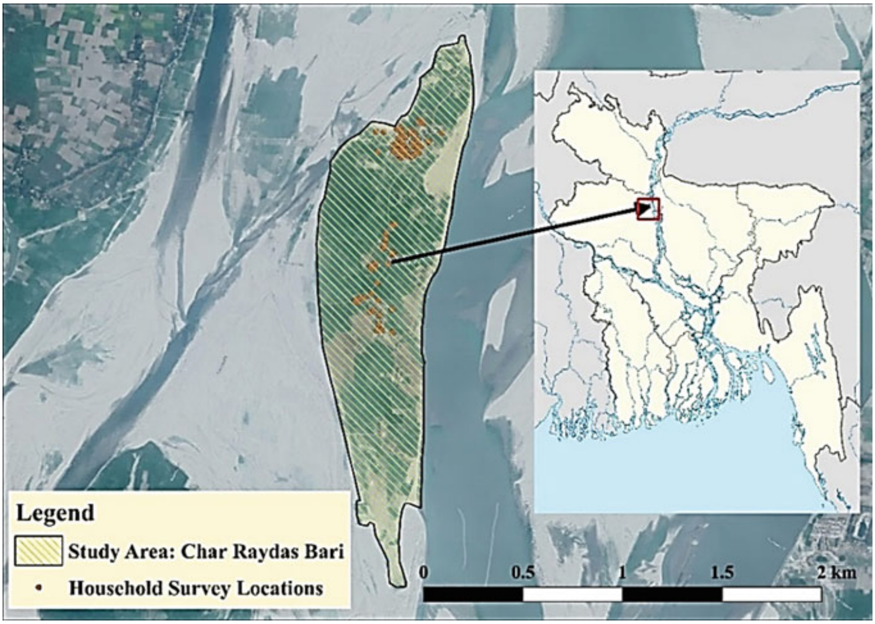

Fig. 16.1 Study area. *Source* Google earth application

Methodology

Selection of the Study Area

The present study was conducted in February 2019 in Raydas Bari Char in Gaibandha Sadar upazila (sub-district) in Gaibandha district in the northwestern part of Bangladesh, approximately 290 km from Dhaka, the capital city (Fig. 16.1). The Char is surrounded by the Brahmaputra River. The soil is sandy to loamy in texture. More than 80% of the inhabitants are directly or indirectly involved in agricultural activities.

Total cultivable land area is 25.63 ha. Major crops are maize, jute, paddy, pumpkin, and peanuts, among other common household vegetables. Drought, riverbank erosion and flooding are commonly faced natural disasters. This char was selected for the current study due to its similarity with other chars in the floodplain where it belongs.

Sampling and Data Collection

The study used household survey questionnaire as well as focus group discussions (FGDs) for collecting necessary data from the study area, using simple random sampling methodology. A total of 98 households were selected for the survey. Two FGDs were conducted with mixed groups, including women, for collecting of qualitative information. The survey included demographic information on household head and family members, land types and land use pattern, frequency and types of hazards and vulnerabilities faced, and climate change adaptation strategies in agriculture. Information on the study area and qualitative data were obtained from local experts and government agricultural and extension offices and non-government sources.

Char dwellers, especially farmers (male and women) were the primary respondents for the study. However, field data collected through the survey were verified and triangulated through secondary respondents from elected representatives, religious leaders, media and the academia.

Data Analysis

Quantitative and qualitative information gathered from the field were processed using standard procedures. Maps on topography, drainage basin and water streams were developed using SENTINAL 2 satellite data. Maps on annual flood and general temperature were produced using LANDSAT 08 satellite and world climatic data, using different bands. Initially a suitable satellite image was downloaded using the USGS Web site, which was later exported as a map layout for further analysis.

Results and Discussion

Findings of the study are presented in the following four sub-sections dealing with (i) socio-demographic and economic characteristics of char dwellers; (ii) geography and climate of the study area; (iii) natural hazards and vulnerabilities in char areas; and (iv) community-based agricultural adaptation strategies of char dwellers.

Socio-Demographic and Economic Profile of Char Dwellers

There are several variables that describe demographic characteristics of the respondents. The variables included in this analysis were respondent and their family members' age, gender, education level, family size, primary occupation, annual family income, farm size, farm types as well as years of agricultural involvement. Table 16.1 present a summary of the findings. Although 98 households constitute the sample, the table contains heads of households data for family size, annual income, farm size, and agriculture as primary occupation; for the rest, other members within the households were considered.

Table 16.1 Socio-demographic and economic characteristics of the char dwellers

Characteristic	Scoring system	Categories	Respondents	
			N	(%)
Age	Years	Young (≤35) Middle (36–50) Old (>51)	278 66 43	71.83 17.05 11.11
Gender	Code	Male (1) Female (2)	205 182	52.97 47.03
Education	Year of schooling	Illiterate (0) Can sign only (0.5) Primary Level (1–5) Secondary level (6–10) Above secondary (>10)	64 105 120 39 12	18.82 30.88 35.29 11.47 3.53
Family size	Number of persons	Small (up to 4) Medium (5–6) Large (>6)	64 33 1	65.31 33.67 1.02
Primary occupation	Code	Farming (1) Day Labor (2) Housewife (3)	125 103 99	38.23 31.50 30.28
Annual family income	USD	Low (up to USD 600) Medium (USD 601–1000) High (>USD 1000)	70 18 10	71.43 18.37 10.20
Farm size	Acres	Small (up to 2.4 acres) Medium (2.5–7.4 acres) Large (>7.5 acres)	91 5 2	92.86 5.10 2.04
Farm types	Code	Owned (1) Shared (2) Leased (3)	86 11 104	42.79 5.47 51.74
Agriculture as primary occupation	Number of years	Low (up to 5) Medium (6–15) High (>15)	9 21 68	9.18 21.43 69.39

Source Field Survey, 2019

Results presented in Table 16.1 show that more than 70% char dwellers are within the young age group (≤35 years) and the rest 30% belong to the middle (36–50) and old (>51) age group. Out of all the responses, 52.97% were male and 47.03% female. The ratio was very close to the national ratio (BBS 2012). However, in other areas, the social profiles of households in the char appear below the national average. For instance—(i) the literacy rate is only 50% compared to 72% nationally; (ii) over 71% of the char dwellers reported an annual income equivalent to USD 600 or $50 dollar a month; (iii) two-thirds of the households have small family size (65%), largely due to fragmentation of the family resulting from displacement and migration; (iv) nearly 70% of the people are involved in agriculture and wage/day labor; and (v) finally, over 90% are small farmers; (most of the lands under cultivation being charlands without ownership).

A number of NGOs have been found to operate mobile schools on boats, traveling from one char to another. Besides, health workers from certain local NGOs visit the study char from time to time and arrange small health camps that are attended by men as well as women.

Geography and Climate of the Study Area

Figure 16.2 provides a comprehensive topography and climate data on the study area. It lists (a) topography of the study char; (b) drainage basin of the study char and its surroundings; (c) water streams of the study area; (d) annual flood of the study area; (e) temperature pattern of the study area and its surroundings.

From satellite mapping, it has been observed that bulk of the residential area of the char inhabitants occupies the highest elevation at 18–22 m above sea level. The topography also has land areas as low as 12–15 m above sea level, which accommodates water in case of flooding. From contour variation study based on satellite imaging, the surrounding areas can drop to as low as 2–3 m above sea level (Fig. 16.2a). Given the variation of elevation in the char areas, low lying areas have been designated as drainage or catch basin where rainwater would collect and drain into a freely flowing outlet such as streams and rivers. These catch basins have also been mapped out to evaluate the proximity of the drainage/catch basin to residential areas (Fig. 16.2b).

In connection with these catch basins, water streams have also been identified rooting from the water collection systems. Besides, the direction of flow where these streams run into, the velocity of flow has also been distinguished from low, medium to high-level streams (Fig. 16.2c). From visualization and analysis of streams, the flood prone areas were further mapped out to predict which land distributions were most likely to be the areas to increase in water depth during rains and floods affecting agricultural crops and housing in some instances. The annual flood data analysis derived from LANDSAT 8 satellite data and world climatic data (Fig. 16.2d) suggest average temperature of 32 °C and higher. The climate data, in addition to flood and ongoing erosion of charlands, indicate relationships and impacts on life and livelihood of the char dwellers.

Natural Hazards and Vulnerabilities in Char Areas

The char dwellers of the study area experience multiple climatic hazards such as drought, floods, and erosion. Their impact rating perception is shown in Table 16.2. They experience a variety of impacts on agriculture, including infestation of pests, loss of soil fertility, decline in production, etc. due to these natural disasters. Due to frequent calamities, agricultural lands have been less productive due to cycles of destructive effects on precious crops and land. The disparity in the weather conditions increases the degree of infestations by pests of agricultural crops as the change in

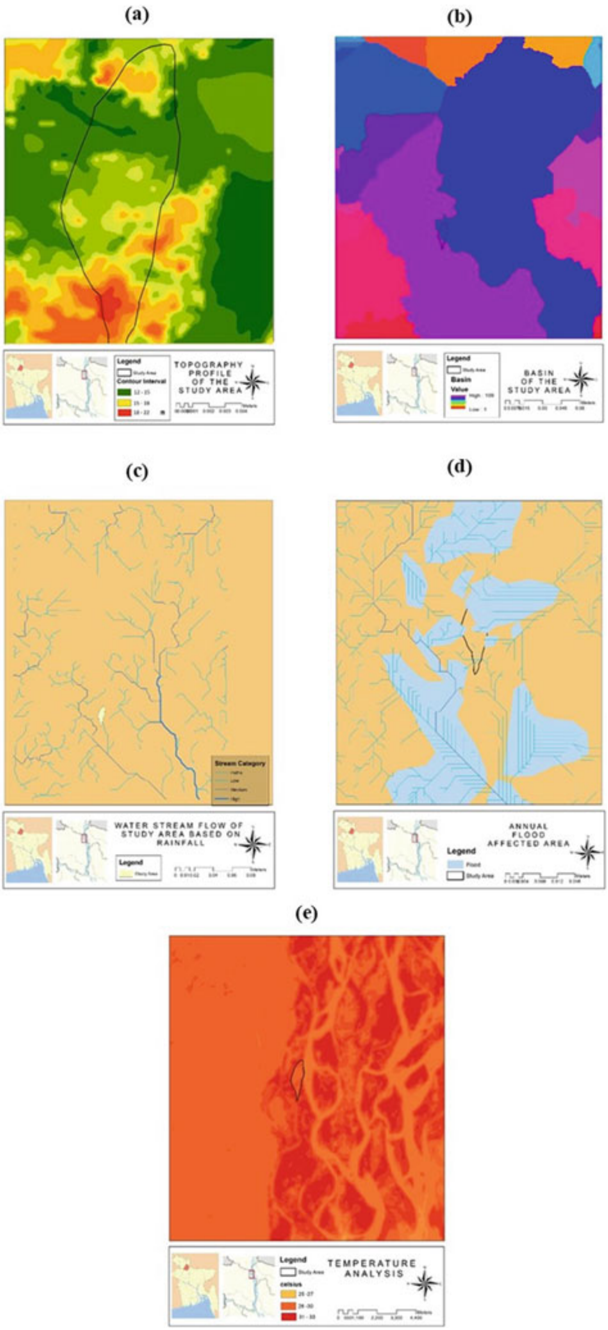

Fig. 16.2 Topography and climate data on the study area. *Source* SENTINAL 2, LANDSAT 8-band 10, 5 and 4 satellite and world climatic data

Table 16.2 Char dwellers' impact rating perception on local hazards and vulnerabilities

Hazards and vulnerabilities	Impact rating (as perceived by char dwellers)
Irregularity of rainfall occurrence	Moderate
Extreme summer	Severe
Extreme winter	Moderate
Prolonged drought	Severe
Increasing occurrence of strong winds/storms	Moderate
Increasing flooding events	Very severe
Riverbank erosion	Severe
Irregularity of rainfall occurrence	Moderate

Source FGD 2019

weather creates growth and proliferation of pests and other biotic insects. Increase in infestation of pests gravely affects proper plant growth, quality of crops and level of crop production (Chattopadhyay et al 2019). This not only affects the current conditions of crops but also the sustainability of crop production by compromising the quality of the next batch of crops.

Besides pest problems, the quality of soil is also affected by the climatic conditions such as the velocity of rivers and the volume of the water within the river system. As a result, the integrity of soil to support living agricultural crops is compromised, thus decreasing surface area usable for planting and production. Ultimately, the total yield of production significantly decreases due to climatic conditions. From agricultural supplies to marketable products, this decrease in production remains a threat to food security in the chars affecting the living conditions and overall health of the people (Rahman and Rahman 2019).

Household perceptions of climate change and variability were also supported by the observed scientific data (Figs. 16.3 and 16.4). *Kharif* season (May to October) is the main cropping season in Bangladesh, but due to problems in arranging essential irrigation facilities during this season in char areas that are characterized by sandy soil texture and high level of evaporation, most of the char farmers keep their land fallow during the *Kharif* season. Thus, char farmers cultivate their land mainly during *Rabi* season (November to April) when temperatures are lower and water retention capacity of the soil is favorable.

Analysis of observed data in Figs. 16.3 and 16.4 support the contention above. All this points to the fact that change in climate makes people in chars vulnerable to certain natural hazards. The char dwellers are one of the poorest and most vulnerable people. Those living on exposed riverbank areas experience similar kinds of problems (Islam et al. 2015). According to Bhattacharya et al. 2016, about 80% of Bangladesh's landscape is prone to flooding, resulting in loss of access to the cultivation fields, whereby char dwellers run a very high risk of losing their livelihoods.

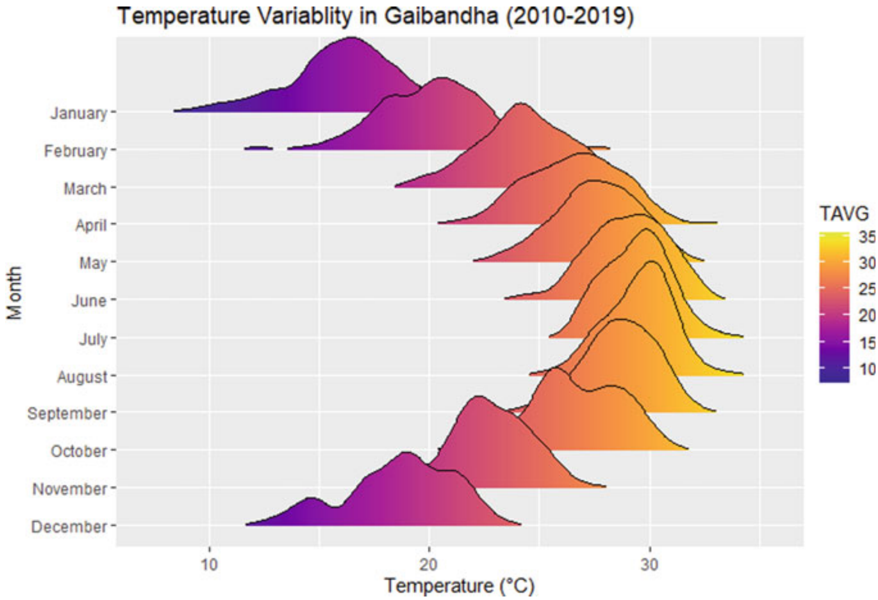

Fig. 16.3 Monthly mean temperature variability near the study char. *Source* Global Surface Summary of the Day Weather Data

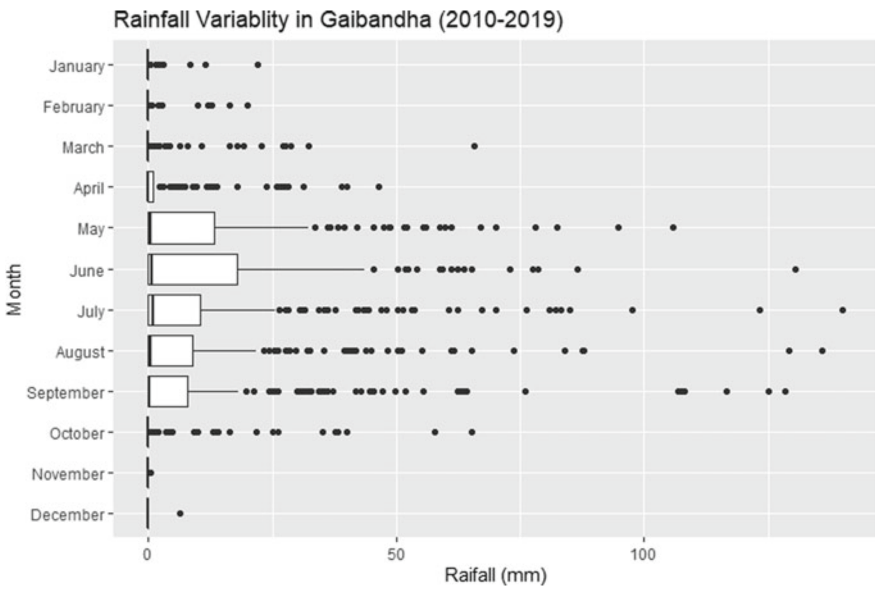

Fig. 16.4 Monthly mean rainfall variability near study char. *Source* Global Surface Summary of the Day Weather Data

Historical data show continuous changes in climate condition, affecting livelihood status of the char inhabitants (Hossain et al. 2019). Char dwellers' lives and livelihood are highly vulnerable to frequent flooding, continuous erosion, and seasonal weather extremes (Rahman and Rahman 2019). These calamities are expected to continue with the changing climate and could potentially result in more destructive outcomes. The floods are expected to be more frequent due to the increase in water volume from melting glaciers, rise in sea levels and more powerful surges of water from the river systems (see Chap. 11). This would result in persistent riverbank erosion and increased incidences of landslides. People living in the study area were found aware of the hazards and vulnerabilities, adopting different kinds of community-based adaption measures to reduce the adverse effects of climate change.

Community-Based Agricultural Adaptation Strategies

The rapid change in climatic conditions is adversely affecting different sectors globally. The current trend indicates that the adverse impacts of climate change are likely to intensify with the increased emission of greenhouse gases into the atmosphere. Agriculture is one of the sectors that has been hard hit by adverse impacts of climate change, particularly in the chars (World-Bank 2013). Therefore, it is important to initiate and implement adaptation strategies that can safeguard agricultural productivity from the harsh effects of climate change. It entails actions taken by nations, communities and individuals toward reducing climate change impacts and adjust where necessary (Akinnagbe and Irohibe 2015). In char areas, some of the adaptation initiatives could include planting crops that can bear with drought conditions, making adjustments in the cropping patterns, initiating soil conservation measures and facilitating agroforestry.

A major objective of community-based adaptation is to incorporate the susceptible people into the establishment and implementation of adaptation processes. In mitigating negative impacts of climate change, community-based adaptation strategy are essential as it is locally focused, locally owned, and also cost-effective (McNamara and Buggy 2017). Community-based climate change adaptation is grounded on the proposition that local community people have the acquaintance and familiarity to undertake locally existing activities that enhance resilience and lessen susceptibility to adverse impacts of climate change (Dodman and Mitlin 2011). Through the assimilation of information from multiple sources, and the engagement of decision-makers, community-based climate change adaptation can be a valuable strategy, creating a sense of belongingness and alleviating climate change impacts.

The community-based climate change adaptation framework (Fig. 16.5) has four major domains, namely, climate adaptable livelihoods, climatic risk reduction, identifying vulnerability and local adaptive capacity. These four domains were influenced by the policy domain and are susceptible to external risks. Community-based climate change adaptation framework is based on the community people's knowledge and

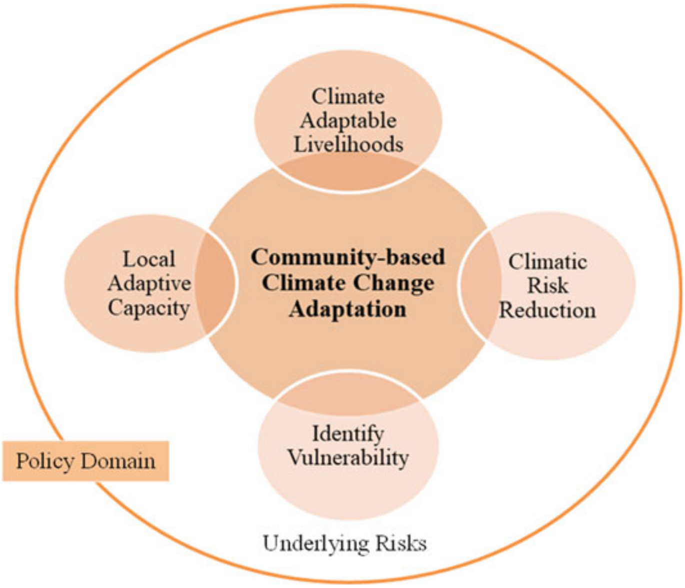

Fig. 16.5 Community-based climate change adaptation framework. *Source* King, 2014 modified

familiarity in utilizing locally available resources toward enhancing resilience and reducing susceptibility to adverse impacts of climate change.

There are several forms of adaptation to climate change in the context of agriculture, such as policies, access to climate information, new cropping patterns and technological adaptation. According to Lein (2009), char areas are mainly vulnerable to flood, riverbank erosion and drought regardless of their geographical location. Char dwellers use their trial and error knowledge and adapt to the impacts of climate change. The adverse effects of climate change like drought, flood and riverbank erosion can considerably reduce agricultural productivity. According to Hossain and Da Silva (2013), small-scale farmers are the main victim of these impacts, who mainly depend on rain-fed agriculture.

Climate change adaptation approach is an essential approach because of its locally focused, locally owned, and cost-effective characteristics (Hagedoorn et al. 2019). Studies have shown that adaptation strategies need to rely on the knowledge and technical know-how of the locals on climate change (McNamara and Buggy 2017). People at risk in the charlands and in the floodplains are taking coping and adaptation measures with their limited knowledge and resources. It is important to make better use of the types of strategies char dwellers have adopted locally in order to mitigate the impacts of climatic change in their community. In the current study, the char dwellers were found adopting multiple strategies for securing their livelihood resilience.

According to Levina and Tirpak (2006), char dwellers mostly practice two types of adaptation: Individual Level Adaptation (ILA) and Planned Adaptation (PA). Individual Level Adaptation is not necessarily a direct response to climate change, but is triggered by ecological, economic, or welfare changes in the existing system, which is the result of private adaptation, initiated and implemented by individuals or households. Example of ILA includes changing planting time, cultivation of short duration varieties, crop rotation, mixed farming, etc. Planned Adaptation is usually directed by the collective needs of people but implemented mainly by the government or NGOs. Example of PA includes adoption of new varieties, tree plantation, introduction of rainwater harvesting technology, etc. After several rounds of sitting with char community leaders, nineteen local adaptation strategies have been identified (Table 16.3).

Many char dwellers reported adoption of multiple strategies. Relatively common strategies include adoption of new varieties in farming practices, utilizing water intensive irrigation facilities, changing planting time and plot sizes for cultivation, cultivation of short duration varieties, crop rotation and livestock rearing.

Table 16.3 indicates various adjustments tried by the char dwellers in their attempts at reducing the adverse impacts of flood, drought and erosion—for instance, changing cropping patterns, introducing new crop varieties, managing soil and irrigation system, changing planting schedules, cultivating of short duration varieties and going for mixed farming. The farmers were found cultivating new crops, like maize,

Table 16.3 Community-based climate change adaptation strategies in the study char

Adaptation strategy	Responses (%)	Comments
Adoption of new varieties in farming practice	82.65	ILA/PA
Water intensive irrigation facilities	75.51	ILA/PA
Changing planting time	74.49	ILA
Changing plot sizes for cultivation	68.37	ILA
Cultivation of short duration varieties	63.27	ILA
Crop rotation	62.24	ILA
Livestock rearing	50	ILA/PA
Mixed farming	42.86	ILA
Cultivation of maize	42.86	ILA
Cultivation of HYV crops	39.8	ILA/PA
Cultivation of vegetables	36.73	ILA
Cover cropping	33.67	ILA
Off-farm work	28.57	ILA
Biological pest control	26.53	ILA/PA
Inter-cropping	15.31	ILA
Homestead gardening	12.24	ILA
Rainwater harvesting technologies	9.18	ILA/PA
Tree plantation	6.12	ILA/PA
Poultry rearing	6.12	ILA/PA

Note Multiple responses were counted. *Source* Field survey, 2019 potato, jute, paddy, and pumpkin; cultivating drought-resistant crops; or planting short duration crops, like potato, tomato, and peanuts.

Summary and Conclusion

Natural hazards and vulnerabilities are fairly common in char areas. However, people living in char regions have always adapted to the vagaries of nature both at individual and community levels. As evident, charland farmers have obtained positive results through community-based adaptation practices, thereby enhancing agricultural productivity. It is necessary to adopt policies to support these practices even more for the betterment of char communities in their adjustments to riverine hazards. It is, therefore, important to further assist in strengthening the adaptation strategies for protection of agricultural production in char areas from the adverse impacts of climate change. This will in turn improve livelihoods of the char dwellers.

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Chapter 17
Crop Production Patterns and Marketing in Char Areas: Adapting to Hazards and Vulnerability

M. Aminur Rahman, M. Shahjahan Mondal, Hamidul Huq, Nandan Mukherjee, and M. Rezaur Rahman

Abstract Agriculture is the means of livelihood for most of the people living in chars in Bangladesh. However, due to the dynamic hydro-morphology and distinct physiography, these chars are highly vulnerable to hazards like flood, erosion, drought, hailstorm and cold wave, which substantially affect agriculture in those areas. This chapter highlights the coping strategies and adaptation measures adopted by char dwellers in view of these hazards from a market system perspective for three common crops—chilli, maize and jute—found in char areas. Case study locations include chars along the Jamuna River. Following the approach of participatory research, information was collected from input sellers, producers, traders, processors and retailers associated with chilli, maize and jute marketing system. Agriculture in chars surely faces additional uncertainty due to environmental hazards that ultimately results in financial losses for the producers. After a careful analysis of a range of potential adaptation options in agriculture, the current study recommends a number of measures that address the specific needs in the context of chars.

Keywords Agriculture in charlands · Production risks · Marketing systems · Adaptation to hazards and vulnerability · Agriculture extension services

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Introduction

The life and livelihood of char people in Bangladesh are strongly dominated by crop agriculture. Among the crops grown in chars, chilli, maize, jute, rice, peanut, wheat, millets, oilseeds, onion, garlic, sugarcane, peas and pulses are the most common. The crops are more diversified during the *rabi* season (mid-November to mid-March) because of favorable hydrological and climatic condition during this period. Jute is the single most dominant crop in the *kharif-I* (mid-March to mid-July) season and *aman* rice in the *kharif-II* (mid-July to mid-November) season. Usually two crops are grown in a typical charland. On sandy soils, a single crop, such as peanut, millet or pulse, is grown in the *rabi* season. On lowlands, two rice crops (*boro* rice—local *aman*) are cultivated in a small scale. Growing three crops, such as maize–jute–rice, is often observed in attached and matured chars. However, the dominant cropping pattern is chilli/maize and jute/rice.

In most chars, crops are less diversified than comparable mainland areas, and *rabi* crops during winter are the only secure crops. Dynamic and highly variable river morphology, absence of flood control infrastructure, and remoteness from support services render char crops more vulnerable to hazards than the mainland crops. Factors like hydrology (flooding and drainage), soil and climate condition, household food security, market price and local cultivation practices are the major determinants of cropping patterns in *char* areas.

This chapter is based on a study by the Postgraduate Programs in Disaster Management of BRAC University and the Institute of Water and Flood Management of BUET (IWFM and PPDM 2013), which investigated how the marketing systems in chars that often gets disrupted by hazards like flood, erosion, droughts and cold waves, could be reorganized to the advantage of crop cultivators living in riverine chars in Bangladesh.

Objective and Methodology

The broad objective of this chapter is to assess the impact of natural hazards on the marketing systems of chilli, maize and jute produced in chars, analyze current coping strategies, and recommend preparedness, response and recovery strategies for future interventions. It specifically highlights the coping strategies and adaptation measures across the marketing systems for the three selected crops. The material presented here is primarily based on a study conducted in chars in Sirajganj, Bogra, Gaibandha and Jamalpur districts along the Jamuna River. The selected locations in the four districts were visited by the multi-disciplinary study team. Data were collected over the months of August and September 2013 from the chars of the Jamuna River under the jurisdiction of the districts mentioned above (Fig. 17.1).

Methods for data collection included key informant interviews, group discussions, focus group discussions and general observations during visits to the chars. The respondents included actors along the crop-specific marketing systems, i.e., producers, input suppliers and small, medium and large traders at the local level. The interviews were done in an iterative manner, allowing the team to follow leads from one interview to the next. This was done to understand the situations within the value chain. In conducting pertinent analysis for the study, the hazard-vulnerability nexus that incorporates socio-economic as well as biophysical environment relevant to the overall marketing system was taken into account.

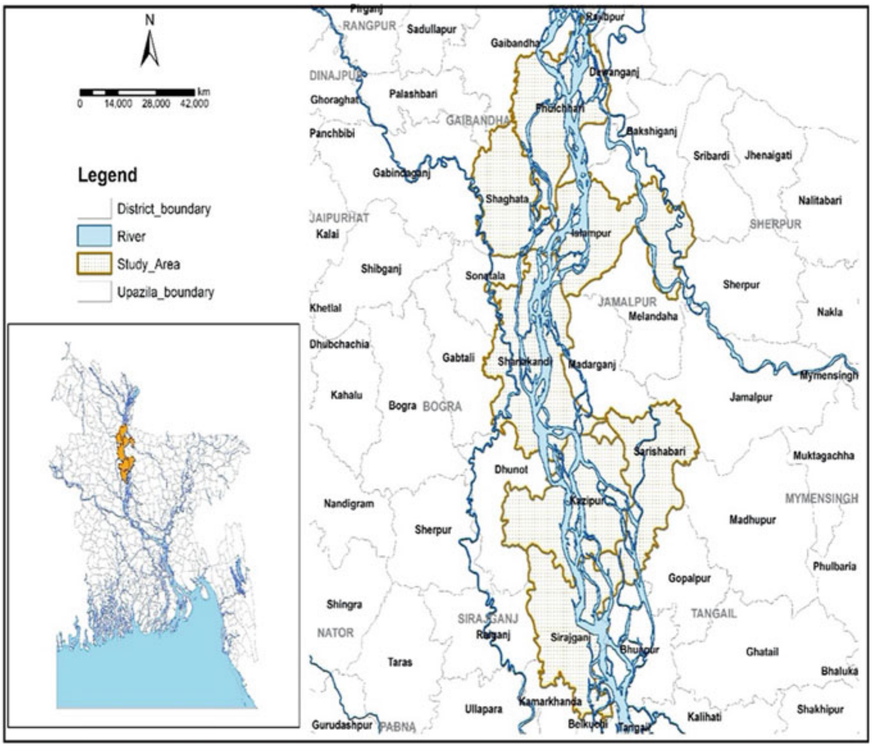

Fig. 17.1 Map of the study area

Markets and Marketing Systems

There are a number of actors in the markets for chilli, maize and jute. In general, five different types of actors can be identified—input sellers, producers, traders, processors and retailers. The input retailers usually sell three different inputs: seeds, fertilizers and pesticides to char farmers. In case of chilli, farmers preserve and store their own seeds.

Chilli farmers sell both green and dry chillis. Some portions of dry chillis are sold immediately to meet farming expenses and some portions are stored for selling later in the hope of better price. There are different types of traders, small and large, who buy both green and dry chilli. Small traders purchase chilli from the farmers and sell to other large traders. It is not common for these traders to own storage facilities. Large chilli traders mostly purchase bulks from small traders and farmers. They sell the purchased chilli to the chilli wholesalers. Also, they sell it directly to the industrial processors, contractor/commission agents. Commission agents purchase dry chilli from large traders, small traders and farmers on behalf of the industrial processors. The chilli processors are large commercial enterprises, mainly buying dry red chilli.

In case of maize, small traders collect the crop directly from farmers and sell to wholesalers/large traders located in the mainland markets. These wholesalers/large traders stock the product and wait for the price to rise. Few maize contractors can be found in the chars of Bogra and Gaibandha. Contractors are basically local maize traders. They provide quality inputs (seeds, fertilizers, pesticides and irrigation facilities) to farmers in credit. In addition, they also offer a buy-back guarantee to the farmers. After the harvesting period, they buy maize from farmers and sell to large feed mills. In some cases, they provide the farmers with technical know-how related to maize cultivation. Large feed mills buy the bulk amount of maize from whole sellers and contractors to produce poultry and fish feed. Feed mill owners engage commissioned buying agents to collect maize from different sources. There are also some starch companies who buy maize from the market.

The traders of jute are the small traders, locally known as *Forias*. They purchase the stock from the local farmers. Medium traders, locally called *Beparis*, purchase jute from the producing households. Moreover, the large traders, locally known as *Mohajons*, buy jute from the small and the medium traders. They sell the jute to both public and private jute mills, large trader-cum-stockists and large trader-cum-exporters. New emerging additions to the market chain are the shippers who buy the jute from the *Mohajons* and *Beparis* of various *bazaars* (markets), eventually exporting it as raw material. At the end point of the market chain are the jute mills or the processors. The product is bought in bulk, some of the mills export raw jute, while others produce jute goods and yarn.

Impacts of Natural Hazards on Production and Market Systems

There is a range of hazards affecting production as well as marketing systems for chilli, maize and jute in the char areas. These include rain, flood, drought, erosion, sand deposition, heat wave, cold wave, fog, wind, various diseases and pest infestation. The char hazards are mostly hydro-meteorological in nature and vary with season and crop. Some hazards like flood occur frequently in the chars, while others such as hailstorm are infrequent and localized. Erosion varies from char to char and sand deposition depends on the age and relief of a char. Also, the frequency and intensity of some hazards such as flood and pre- and post-monsoon rain are increasing (see Chap. 11). The cropping process being highly dependent on nature, the impacts are mostly borne by the crop producers. The medium and large traders and processors are not as affected. The following sub-sections present some details regarding impacts of different hazards on crop-specific market systems as found in the study locations.

Chilli Production and Marketing

Cold wave affects chilli plants significantly in all four districts (Sirajganj, Bogra, Gaibandha and Jamalpur). Cold wave causes withering of flowers and of leaves, turning them black. Another hazard affecting chilli plants is hailstorm which also causes shedding of leaves of the standing chilli plants. This reduces the yield substantially.

Chilli producers believe regular flooding is essential in renewing soil fertility for subsequent cycle of production. In their opinion, chilli plants stay disease-free over a couple of seasons following a flood. However, flooding during the late and post-monsoon period (September–October), which is prime time for sowing of chilli seeds, can delay the process of cultivation, resulting in low yield. Thus chilli producers in Bogra reported that late monsoon flood in their area was responsible for poor yield of their chilli.

Rain does not have much impact on cultivation of chilli in char areas as the natural drainage process does not allow water to stand on the land for too long. However, if sowing seeds is delayed due to heavy rainfall, there can be substantial loss in yield. In Sirajganj, a group of farmers reported that a three-day delay in sowing seeds owing to heavy rain resulted in reduction in yield. Besides, excessive rainfall damages the grownup chilli plants.

Rain is a greater concern for the chilli growers following harvest, when they need to dry the chillies. Since chilli is almost exclusively sun-dried, the process gets impeded by cloudy weather and rain. Moreover, if chillies cannot be dried up shortly after harvesting, a portion could get rotten, the rest turning low in grade and hence selling for lower than the desired level of price.

Chilli farmers in the study areas commonly reported diseases to have caused substantial damage to chilli plants. These diseases include rotting of roots and stem of plants, roots turning black and yellow in some cases. Though the farmers are not sure about the causes of these diseases, they assume these could be due to low-grade seeds or adulterated fertilizers they unknowingly use. It was curious to find that even a block supervisor of the Department of Agricultural Extension in Gaibandha was unaware of the real causes of these diseases.

Maize Cultivation and Marketing

Maize is an irrigation intensive crop. Agriculture requires complementary irrigation during periods of drought, which most producers cannot afford. Hence, 'compromised irrigation' results in 'compromised yield'. Fog and cold wave retard the growth of maize plants. They cause withering of leaves and as a result, yields get reduced.

Grownup maize plants are amenable to damage by strong wind. The slender stem of tall maize plants cannot withstand high wind and hence fall offs are very common scenes in the vast plains of chars growing maize. The result is substantial loss in yield. Pre-monsoon (March–May) rain hinders the sun-drying of maize, causing degradation of harvest quality. Normally producers tend to sell off maize grains soon after separating the corns from the cobs and the small traders (*Foria*) or the *Chatal*[1] owners usually carry out the drying part. If the drying process is delayed due to rain, maize grains soon germinate and fail to qualify for good price.

Jute Cultivation and Marketing

Jute cultivation is vastly dependent on rain. Absence of timely rain necessitates substantial irrigation, which raises the cost of cultivation. Failure to arrange for irrigation results in low yield for many producers. Starting with the sowing of seeds in mid-March, young jute plants require nourishment; but meteorological drought at the beginning of the *Bangla* (Bengali) month of *Ashar* (mid-June) causes massive damage to young jute plants. Farmers who aspire for higher yield and better price go for complementary irrigation through shallow tube wells. But financial constraint does not allow most of the producers to adopt this option. Shortage of water also impedes proper retting of harvested jute, which consequently produces low-grade fiber. Continued rain, on the other hand, restricts drying of jute. Unlike chilli and maize, jute fiber requires more space for storage, which is an added burden for jute producing households.

The jute growers who cannot afford complementary irrigation to initiate the cultivation process are eventually caught up by flood before harvesting time. The late

[1] *Chatal* is a large leveled and predominantly cemented floor area used for drying crops. In Bangladesh, large traders have their own *chatals.*

monsoon flood, usually in the month of September, substantially damages juteyield. During field visit in Jamalpur, the research team found a large area of land with mature jute plants submerged in flood water.

Coping Practices and Adaptation to Hazards

Using plastic sheets or tarpaulins for drying of chilli and maize grains is a recognized and effective practice found in all the case study districts. This is because tarpaulin significantly reduces the time required for sun-drying of these crops. Besides, drying on plastic sheet or tarpaulin helps avoiding degradation of the quality of chilli and maize grains as it prevents mixing of sand while drying. Producers and small traders requiring to dry such produce reported not knowing of the use of tarpaulin for drying before it got popularized by certain NGOs. However, cost of tarpaulin was reportedly beyond the reach of a large number of producers.

Large traders (*Chatal* owners) use wide cemented surface for sorting and drying of chilli and maize (see Figs. 17.2 and 17.3). But in the event of incessant rain over a number of days, the drying process gets delayed, with the associated risk of missing shipments to the processors. The *chatal* visited in Bogra was found to have the facility of mechanical drying, but the owner reported that it was highly power intensive and hence not cost-effective.

Chilli producers tend to sell off their yield soon after harvest as they do not have appropriate provisions for preservation and storage. Even if the farmers are willing to preserve chillies for higher off-season selling price, they are unable to do so due to lack of knowledge about preservation tools and techniques. The traditional means of preservation, which is to store the dried chillies in plastic bags/ sacks, does not prove to be appropriate as they cannot protect the chillies against moisture and as a result the quality of chillies is degraded. Same is the case with chillies they save for seeds;

Fig. 17.2 Chilli drying at a *chatal* in Bogra. *Source* Research Team 2013

Fig. 17.3 Crops covered against rain at another *chatal* *Source* Research Team 2013

such stocks ending up with low grade seeds only due to inappropriate preservation, which consequently leads to poor yield. In combatting diseases and pest infestation, farmers go by the advice of pesticide/ insecticide sellers, who have no institutional training, advising on the basis of directions printed on the package of the products.

The coping practice in case of flood at an early stage of cultivation is simply to redo the process. But, as mentioned earlier, if the ideal time for sowing is missed, the production is much compromised. Besides, many farmers do not have the capital to obtain the inputs (seeds, fertilizer, pesticide, and above all, labor) for re-cultivation. In many instances, it has been reported that farmers sell off their cattle to obtain the capital they need for crop cultivation. Besides, they purchase low-grade/adulterated seeds for jute and maize to minimize cost(seeds for chilli usually preserved). Flood at an advanced stage of cultivation does not leave any option but to accept the loss, which is difficult for most of the farmers to digest. Sometimes they try out short-term crops to make up for the loss. Often the deposition of alluvium on arable land through flooding hinders regular cultivation; however, farmers in chars sometime produce sugarcane, groundnut/peanut, onion, pumpkin and vegetables as "chance" crops in the face of uncertainties.

The coping strategy against shortfall of rain is to provide complementary groundwater irrigation. But, because of costs associated with groundwater irrigation, in most cases farmers keep their fields under-irrigated and hence end up with low yield. Based on the field-level data and local consultation, Table 17.1 presents a summary of crop-specific hazards, their impacts and coping across market actors. The producers of different crops bear the brunt of the losses caused by natural hazards. The *Foria* or the middlemen, on the other hand, are least affected by such losses.

Table 17.1 Crop-specific hazards, impacts, coping and adaptation measures

Crop	Hazard	Impact	Coping/adaptation	Affected market actor
Chilli	Flood	• Delays in sowing, resulting in reduced yield	• Redoing the sowing, accepting the (partial) loss	• Producer
	Untimely rain	• Delays in the drying process • Degradation in quality of yield • Reduced income from sales	• Selling of raw, wet and unprocessed produce at low price • Accepting the loss	• Producer • Small traders (*Foria*)
	Cold wave and fog	• Withering of flowers • Withering of leaves	• Applying pesticides/fungicides	• Producer
	Diseases and Pest attack	• Rotting of roots and stems of plants • Roots turning black/yellow	• No effective coping since reasons are mostly unidentified	• Producer
	Hailstorm	• Shedding of leaves • Low yield	• Immediate harvest of green/ immature crop	• Producer
Maize	Untimely rain	• Drying of maize grains hampered • Degradation in yield • Reduced income from sales	• Selling of raw, wet &and unprocessed produces at low price	• Producer
	Drought	• Reduced yield	• Providing irrigation with Low Lift Pump (LLP)/ Shallow Tube well (STW) (most farmers cannot afford)	• Producer
	Cold wave and fog	• Retarded growth of plants • Withering of leaves • Low yield	• Applying pesticides/fungicides	• Producer
	Wind	• Falling of grownup plants Reduced yield	• Some farmers grow low-height variety	• Producer
Jute	Flood	• Damage to grown up plants • Early harvesting, resulting in low grade jute fiber	• Early harvesting • Absorption of loss incurred	• Producer

(continued)

Table 17.1 (continued)

Crop	Hazard	Impact	Coping/adaptation	Affected market actor
	Shortage of rainfall	• Calls for complementary irrigation during cultivation, increasing the cost of production • Reduced yield • Following harvest, impedes the retting process, resulting in low-grade jute fiber	• Complementary irrigation (most farmers cannot afford)	• Producer
	Excessive rainfall	• Delays the drying process • Drop in price	• Selling of raw, wet and unprocessed produce	• Producer

Challenges for Crop Producers and Recommended Measures

After analyzing the nature and extent of the hazards associated with chilli, maize and jute marketing systems in selected char areas, it is clear that the producers are the ones to be the hardest hit. The actors in the marketing systems, following the producers, are rarely affected by natural hazards and they have immediate means of coping. For example, the input retailers get affected when the cultivation process for a crop is delayed as they have no sales; but they make it up with higher price of inputs (seeds, fertilizer, and pesticide/insecticide) later which eventually affects the farmers. The top order actors, namely *chatal* owners and/or contractors/*arotdars* and the processor are not much bothered by low yield of crops due to hazards as they meet the supply deficit through import which, again, has a far-reaching impact on the farmers.

Re-cultivation after damage caused by pre-monsoon flood calls for additional capital, which is difficult to manage for the subsistence farmers. Farmers in chars may have land, but due to lack of capital they often cannot procure enough inputs for cultivation even during normal/non-disaster time. A maize cultivator in Jamalpur admitted that his yield could have been doubled if he could arrange enough irrigation. And in case of damage of crops due to flood or drought, the shortage of capital is even more acute for starting all over again.

Unlike rest of the country, microfinance agencies/institutions or NGO organizations are nearly absent in the study areas. In few instances where they can be found, their weekly repayment schedule is not favorable for the farmers as they must wait a couple of months for their harvest when they get return on their capital investment. Some informal provisions for loan, mostly from *Mohajan* (usurer) have been noticed, associated with rather high rates of interest. The usual practice is to obtain the seeds and fertilizers on credit from the input retailers (sub-dealers) for which they are charged higher price. However, availing groundwater irrigation and labor for cultivation is still a challenge.

Availability of good quality seeds is a must for satisfactory levels of maize production. Unlike chilli, producers purchase maize seeds from the market. There are varieties of seeds available in the market and prices vary substantially. Farmers in the study area reported significant differences in yield from seeds of different origins/brands.

Some measures are recommended below to help farmers overcome the challenges above in the way of providing storage facilities, credit and miscellaneous extension services.

Provisions for More Storage Facilities

Harvested chilli and maize are stored at least at three points in different amounts/capacities before they are finally delivered to the industrial processors. Chilli is harvested three to five times in a season, dried in sun and stored at the farmer's house, mostly in small quantities. Maize is harvested once in a season, dried and stored before the farmers sell them to *Forias*, who collect the crops moving from door to door. The farmers tend to sell off their crops as soon as they are harvested and ready for selling, understandably to meet up the loan/ cost they have incurred and also for meeting household needs. Sometimes the chillies and maize are under-priced because they are not properly dried. An additional reason for hurried sales is the lack of appropriate storage facility for the crops. Even when they have surplus production and it is known that higher prices could be availed if sold later, such advantages remain out of reach for them due to lack of appropriate storage facilities. Currently, chilli producers in all of the areas visited use large plastic bags (Fig. 17.4) inside jute

Fig. 17.4 Preservation of chilli at household level. *Source* Research Team 2013

sacks to preserve chilli, mostly for seeds for the next round of cultivation and some for selling later.

Some farmers who preserved chilli, hoping for selling later at a higher price, ultimately ended up selling at a much lower price as the chilli got degraded in quality (*fatka*), caused by failure in guarding against moisture due to poor preservation. This often discourages producers in storing chilli for future sales. In this regard, a community barn (*golaghor*) for storing crops in an accessible central place or neighborhood would be helpful for the producers. The design and construction of the ‘store house’ should be such that the stored item is well-guarded against moisture and rodent infestation.

Price of chilli varies significantly in accordance with its quality/ grade and also seasonality, which is all the more reason for ensure proper storage of the harvest. Chilli (and maize) producers can be encouraged to use zipped plastic bags which are considerably air-tight. These could be of different capacities ranging from 2 to 10 kg, for example. This would allow them selling the crops in different quantities as considered judicious, rather than selling in bulk at a price lower than what could be had in future. Chilli (and maize) collected by *Forias* are carried to local *haat* (market) and sold to medium traders (*Mohajans*). Some *Forias* reported that chilli, while being transported to the *haat* by boats, at times gets wet from river water. This can be prevented if they use large plastic bags inside the jute sacks they use during transport.

Access to Credit Facilities

Given the high dependency on nature for cultivation, harvesting and post-harvest activities of chilli, maize and jute, and the type and extent of damage and loss incurred from the hazards discussed, it is necessary to adopt a multidimensional approach toward handling the problem. Crop cultivation is a time-consuming process and it cannot be shortened, nor can the impact be readily absorbed by the farmers. They sometimes have difficulties in ensuring quality inputs (seeds, irrigation, fertilizer and labor) in adequate quantities at appropriate times due to shortage of funds. Timing for use of these inputs is crucial; for example, if the correct time for sowing chilli seeds is missed just by a few days, production drops substantially, even if other inputs are properly ensured, as evidenced in the Bogra chars. Another issue is that of irrigation. Insufficient irrigation reported to have reduced maize production by half in the Jamalpur chars. Access to funding for farmers toward procuring inputs on time and in sufficient quantities could be possible through contract farming. Although contract farming is still at an early stage in Bangladesh, with the growth of industrial processors, particularly for chilli and maize, it seems to hold good prospects for the future.

Alternative Crops and Crop Diversification

The practice of growing short-term 'chance crops' (mostly vegetables) was observed in parts of the study area. These crops are produced when the timing of sowing/ planting of regular crops is missed due to the onslaught of flood, heavy rain, drought or some other hazard. The idea of growing such short-term crops can help farmers cope with the shock of a disaster. To make this work, farmers need to be sensitized and trained as to which specific crops would be the ones to go for, given the quality of soil and climatic issues. Above all, availability of necessary funds for purchase of inputs needs to be ensured, if this strategy is to work.

Drying Facilities (for Chilli and Maize)

As discussed earlier, the conventional drying process (drying on earth surface) degrades the quality of chilli and maize as the crops get mixed with sand. Besides, sudden rain can create additional problems. Introduction of tarpaulin by an NGO has been appreciated by the producers as it significantly reduces the drying time (from 14–15 days to 8–10 days) and also prevents wastage by protecting from getting mixed with sand. It is to be noted that when the surface of tarpaulin is black, it shortens the drying time further.

Prolonged rain over several days can impede the drying process in *chatals*. In a *chatal*, large quantities of chilli and maize are sorted according to grades and then dried before final processing. The *chatal* visited in Bogra was found to have installed an industrial scale dryer to cope with rain (Fig. 17.5). But because of its high price and the high consumption of energy, the owner reported it not to be cost-effective. This diesel operated dryer has been imported from China. Such mechanical devices can be customized and even be manufactured locally at lower costs.

Fig. 17.5 An industrial scale dryer in Bogra. *Source* Research Team 2013

Weather Forecast for Crop Production in Chars

Timely and precise weather forecasting can help reduce the loss and damage associated with rain, windstorm, hailstorm, fog and cold wave. All these hazards, as discussed so far, impact the three crops and hence weather forecasting can play the role of a decision support tool. If torrential rain over an area could be forecasted, farmers would then have the time to revisit their scheduled sowing or fertilizer application, thus reducing chances of loss. Similarly, if the probability of fog and cold wave could be communicated to the farmers, they would be able to take necessary precautions.

In Bangladesh, although there are institutional arrangements in place for weather forecasting, it does not cater to the needs of specific occupational groups, for example, the farmers. Besides, the weather forecasting is done in a generalized manner which applies over a large geographic area within which the forecasted weather may vary significantly. Also, improvements are needed in dissemination for the benefit of people living in char areas.

The Bangladesh Meteorological Department (BMD) is responsible for forecasting temperature, rainfall and other features of weather, information on which is then disseminated through public media (radio and television). But the forecasting by the BMD is based on divisional/ regional scale, which does not help much in decision making by farmers at the ground level. The Flood Forecasting and Warning Centre (FFWC) of the Bangladesh Water Development Board (BWDB) has a useful web-based flood forecasting system, but the challenge again is the dissemination of the forecasts to the *char* people.

Accurate weather forecasting is a difficult task. It might not be feasible to install a state-of-the-art weather forecasting system to help our farmers. However, things can improve by effective dissemination of whatever information gets to be available. Community radio may play a useful role here. Mobile phone-based warning/ forecast may also be an effective way of reaching the char community. Some sporadic initiatives were taken to introduce community-centered warning dissemination based on mobile phone communication, the prospect of which should be further explored. Although weather forecast would obviously not help in all instances, yet it surely can help to a considerable extent.

Summary and Conclusions

Charlands in Bangladesh are faced with significant vulnerability to a variety of natural hazards including untimely or heavy rain, flood, wind and storm surge, cold wave, hailstorm, drought, etc., which adversely impact the production patterns as well as marketing processes in the agricultural sector there The current study, in examining the cultivation of three different crops (chilli, maize and jute) in certain charlands in the Jamuna River system of the country found that among all the market actors, producers are the most vulnerable to these hazards and have to bear the brunt of the resulting losses. The char people with their resilience try their best to cope with the situation in minimizing damage to their crops and also storing these as best as they can for subsequent marketing. To succeed in such efforts, the char dwellers, who have to continuously struggle with these hazards for survival, are in urgent need of a holistic institutional support in terms of microfinance, market linkages, appropriate trainings and miscellaneous extension services to succeed in these efforts toward attaining a sustainable life for themselves in the charlands of the country.

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Chapter 18
Out Migration as a Survival Strategy for Char Dwellers

Hafiza Khatun, Md. Humayun Kabir, and Lutfun Nahar

Abstract The paper investigates migration pattern of char dwellers, their employments and contribution of remittances in socioeconomic and infrastructural development as well as investment in their respective charlands and adjacent areas. Based on primary field investigations in three chars in the Padma, Jamuna and Meghna floodplains, the study reveals that char inhabitants remain in a threat of erosion and periodically migrate as an adaptation strategy to reduce risks and uncertainties. The study found migration patterns seasonal, circular or even permanent to relatively close areas. Remittance is initially spent on household and housing structure maintenance or improvement, children's education and marriage, followed by investment in income enhancement. In some cases, the money is also spent on development of local religious institutions, which help concerned returnee migrants to gain higher social status and take part in community-level decision-making processes. Majority of the migrant women are young and unmarried, spending almost all their earnings for their families with no or limited savings for themselves. The study observes that socioeconomic conditions of communities living in chars can be improved through schemes providing support services to the process of migration.

Keywords Char dwellers · Out migration · Case studies · Use of remittance · Improving socioeconomic conditions

Introduction

Charlands are accreted sandbars generally emerged from the riverbed due to deposition of alluvium in the middle and lower courses of any river. These newly accreted lands called char or *diara*, inhabited by some of the most sidetracked people (Schmuck-Widmann 2001; Baqee 1998). They are thought to have a sub-culture,

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appearing to be somewhat different and distinct from the lifestyles of inhabitants living in the mainland (Zaman 1989). As a riverine country with more than 220 rivers (Rasheed 2008), most rivers have developed chars in their lower courses (Adel 2001).

Thus, char areas in Bangladesh are found in the rivers Ganges, Padma, Jamuna, Upper Meghna and Lower Meghna (Elahi 1991), covering an area estimated at 8450 km^2, with a total population of 6.3 million (Thompson and Tod 1998; Banglapedia 2014). This landform covering 6% of the country's total area hosts nearly 5–7% of the total population. Char dwellers encounter a variety of visible and invisible threats. The most common threats are recurrent flood and riverbank erosion. Sometimes, extreme weather conditions can lower agricultural production and lead to food insecurity, while severe occasional storms are found to cause major havoc for char dwellers.

When people lose their lands and homestead due to erosions, they retreat and/or move to nearby areas as immediate adjustments to displacement; however, in course of time, some or all family members may choose to migrate to local towns or cities of varying distances (Salehin 1991). On arrival, the poor migrants routinely turn to slums and squatter settlements for shelter, thereby causing rapid rises in urban population (CUS 2006). Migration is the upshot of both push–pull factors, while push factors like riverbank erosion, floods, seasonal unemployment, etc. abound in the place of origin, and the place of destination is hoped to offers a range of opportunities (e.g., employment, education, healthcare, etc.) (Krishnakumar and Indumathi 2014). Push factors are the predominant cause of migration for the extreme poor and highly vulnerable char dwellers (Elahi 1991).

Migration is considered a survival strategy and affected households very often have no alternative but to move to nearby towns or cities. Scarce income and employment opportunities are exacerbated by natural disasters. Women living in char areas are among the worst affected with prevalence of dowry, child marriage, gender-based violence, restriction in physical movement and limited say in decision-making within family or community (see Chap. 19). Wealthy interest groups control access to land, while social safety nets targeted at the extreme poor are frequently enjoyed by the non-poor. Geographical isolation and poor governance thus contribute to making the chars an extreme poverty pocket in Bangladesh.

Recent boom in development of industries, construction activities and services in different parts of the country act as pull factors, attracting people to migrate to towns and cities for better fortune. Furthermore, lack of employment opportunities in char areas, cyclic natural disasters, prevailing poverty, faulty power structure, land tenure problem, inadequate civic facilities push char people toward these destinations. Internal migration from rural to urban area is thought to be the major driving force of rapid urbanization, partly attracted by the persistent higher rates of economic growth by 6% or more annually over the past many years. Per year, above 0.6 million people migrate and their income contributes to nearly 10% of the GDP (UNDP 2013). Moreover, Bangladesh stands third among the South Asian countries and eleventh globally in terms of earning foreign remittance (Daily Star 2019). In sum, migration generally brings economic and social changes both at the origins and at destinations.

Objectives and Methodology

This chapter examines the patterns of outmigration from char areas and the impacts of remittance on individual families as well as char communities. An attempt has been made to explore how remittance from outmigration can have significant impact on overall development in the selected char localities. In other words, this chapter examines the twin relations between migration and socioeconomic development in the remote char areas of Bangladesh.

The study is based mainly on primary field investigations conducted in three different chars—Char Tepurakandi in the Padma, Malakandi Char in Meghna and Teligari Char in the Jamuna rivers (Fig. 18.1). Selection of the chars for the study was mainly purposive—three chars from three major rivers, covering Bogura in the north, Faridpur and Chandpur districts in the south. A total of 150 households (HHs) from three study chars (50 HHs from each char) were selected for field survey. The field surveys were conducted in the month of November 2019. Households interviewed were selected randomly among the inhabitants with at least one member in the family as a migrant worker but living in the study chars. In the study chars, between 40 and 50% of the households have experienced migration during the last ten years. In addition to HH interviews, a total of 7 focus group discussions (FGDs)—three FGDs with adult agricultural workers and three FGDs with women in each char and one addition FGD with young males were conducted in Malakandi (Meghna) Char. Key informant interviews (KIIs) with local Union Parishad (UP) Chairmen and members as well as numerous field observations generated useful information for the study. Besides, useful information was gathered through review of pertinent literature.

Profiles of the Study Chars

The study chars differ in terms of their accessibility and level of physical, social and economic vulnerabilities. Among all different vulnerabilities, physical and infrastructural vulnerability are critical, which trigger other forms of vulnerability. Char dwellers' level of income, status of employment, accessibility to resources, marketing facilities, etc. are referred to as their economic vulnerability. Physical or infrastructural vulnerability refers to relative isolation from the mainland, frequency of bank erosion, occurrence of floods, cyclic natural disasters and accessibility to nearby urban or important locations, poor road and communication facilities, etc. Moreover, char dwellers' poor literacy level, governance, level of food security, impoverishment, gender status, women empowerment, accessibility to social resources, etc. are referred to as social vulnerability. In this study, based on perception by the respondents and field observations in the study chars, vulnerabilities have been defined as low, moderate and high (Table 18.1).

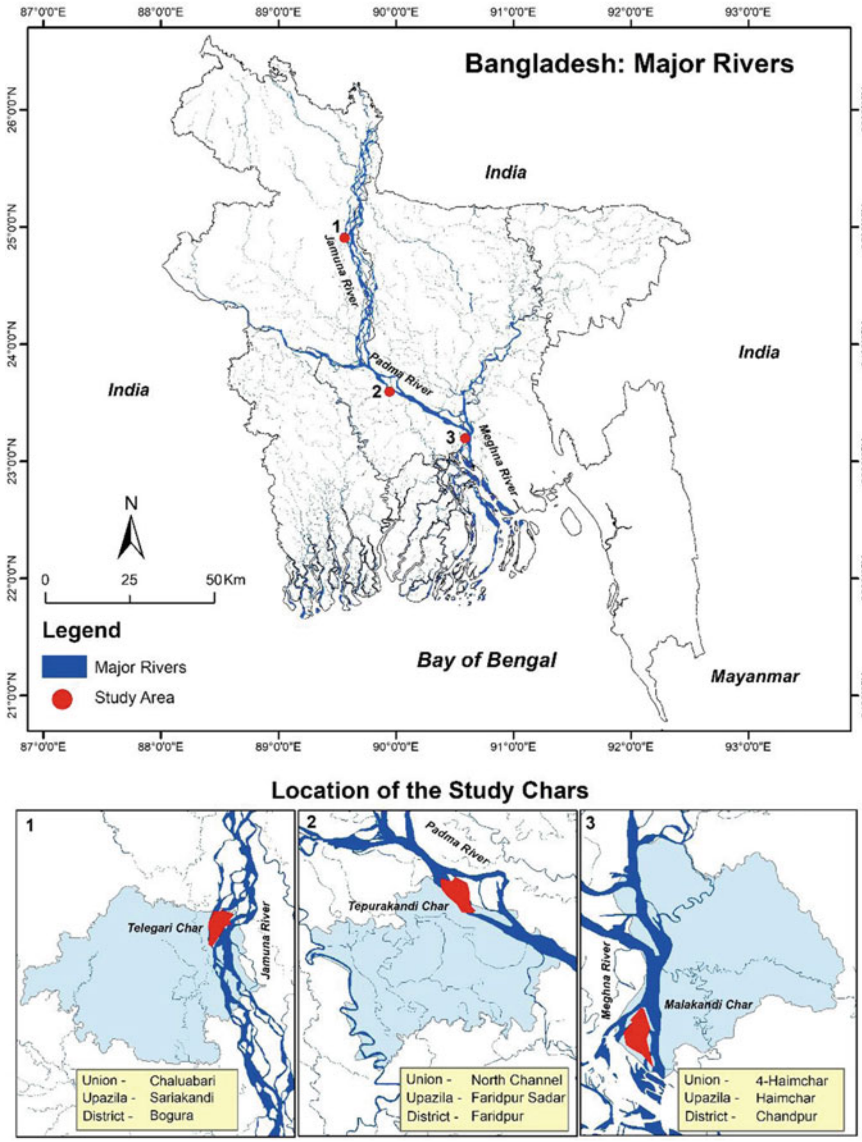

Fig. 18.1 Location of the study chars. *Source* Modified from ASB (2017)

Char Tepurakandi is relatively more stable than the others, followed by Teligari Char, while Malakandi Char is subject to severe riverbank erosion. Almost no permanent infrastructure is visible at Malakandi. Teligari Char is also subjected to erosion but is relatively stable compared to Malakandi. Teligari accommodates nearly 900 inhabitants with a total of 155 HHs with no school. Absence of school is reflected in

Table 18.1 Profiles of the study chars

Char (District)	River System	Type of Char	Relative Vulnerability[a]	Accessibility (to mainland cities)	Institutions	Literacy (%)	Principal Occupation
Teligari *Char* (Bogura)	Jamuna	• Relatively large areal size, detached from mainland, semi-stable	• Moderate vulnerable to natural hazards (floods, bank erosion, drought) • High social and physical/ infrastructural vulnerability • Moderate economic vulnerability	• Access to mainland by boat • Mainland to Bogura town through good road • Very good road and rail communication to Dhaka and other big cities	01 Madrasa 02 Mosques	<20	Farming agriculture, fishing, livestock rearing
Malakandi *Char* (Chandpur)	Meghna	• Separate/ isolated/ detached from mainland, unstable	• High vulnerable to natural hazards (floods, bank erosion) • Moderate economic and social vulnerability • Very high physical infrastructural vulnerability	• Access nearby Chandpur town by boat/ motor vehicles • Ease of access to Cumilla town, Chattogram and other cities through rail and very good road	01 Govt. primary school, 01 high school, 02 Madrasa 02 Mosques	48	Fishing, farming agriculture, livestock rearing

(continued)

Table 18.1 (continued)

Char (District)	River System	Type of Char	Relative Vulnerability[a]	Accessibility (to mainland cities)	Institutions	Literacy (%)	Principal Occupation
Char Tepurakandi (Faridpur)	Padma	• Attached to mainland • Stable *char* land	• Low Vulnerability to flood, river bank erosion • Moderate physical/infrastructural vulnerability • High social and economic vulnerability	• Poor road access to nearby areas, Faridpur and Dhaka city	02 Govt. primary schools 02 Madrasas 05 Mosques	37	Farming, fishing and day laborer

[a]Relative vulnerability refers to variable conditions/status of physical, social and economic aspects of a community. High vulnerability is the extreme/negative exposures of char dwellers and refers to their high risk in different sectors. Moderate vulnerability refers to the relevant parameters as moderate state compared to the surrounding areas, varies seasonally and pushes community to survive at marginal level. Low Vulnerability refers to the relevant parameters in fairly good condition compared to the surrounding areas

Source BBS (2014a, 2015, 2019)

the low literacy rate (<20%) of Teligari (BBS 2014a, b), while the national average literacy rate and that of Bogura District are 51.8% and 49.4%, respectively, (BBS 2015, 2019). Farming followed by fishing and livestock rearing appear to be the principal occupations of this char dwellers. Similar occupational pattern is also observed in Malakandi Char. Total population of Malakandi is around 1800 (257 HHs). It has primary as well as high schools for students, resulting in a fairly satisfactory level of literacy rate of about 48% (BBS 2015). However, schools, madrasas and mosques are the only principal institutions in these chars. Table 15.1 summarizes profiles of the three chars.

It is worth noting that Chandpur district as a whole has higher level of literacy (56.8%) compared to other districts and also the national level (51.8%) (BBS 2014a, b, 2015) despite severe devastation by flood and erosion in the area (BBS 2013). The left bank of the lower Meghna at Haimchar has been eroding for many years. As a result, the downstream of Chandpur District headquarters has been shifting with an average rate of 75 m/year during the period 1929–1988 and at an average rate of 3.92 m/year during the period 1992–2000 (Taleb et al. 2013).

Char Tepurakandi has 6,585 inhabitants (700 HHs) with a literacy rate of 37% (BBS 2015) and people are mostly engaged in farming and fishing, while a significant number of them are day laborers (BBS 2011). The inhabitants experience comparatively extreme variation of weather condition like low and high temperature in winter and summer, severe storms compared to the surrounding areas. In 2019, around 348 hectares of cropland of Faridpur were inundated including Char Tepurakandi (Daily Prothom Alo 2019).

Mobility of Char Dwellers in Bangladesh

Human habitation is common in the numerous riverine chars in Bangladesh. More than 90% char people live in the charlands of the three major rivers—the Padma, Meghna and Jamuna. Living in chars, however, is always a struggle. Thompson and Tod (1998) study reveals that around 0.72 million people in Bangladesh were displaced due to riverbank erosion during 1993–1994. Every year nearly 10,000 hectares of land are eroded by rivers in Bangladesh (MOWR 2001). On other hand, CEGIS (2019) identified 29 spots of riverbank erosions, displacing over 28,000 people. Every year, approximately 12 million people in Bangladesh get affected by flood and riverbank erosion leading to impoverishment; those who suffer most live in char areas (Elahi 1991; Baqee 1997a, b; Schmuck-Widmann 2001). Frequent natural disasters, landlessness, unemployment, low level of literacy, malnutrition, etc. have made char areas one of the most backward and poverty stricken regions in Bangladesh (Sarkar et al. 2015).

Displacement caused by erosion is a common phenomenon in char areas, putting millions of people into prolonged vulnerability (Islam and Khatun 2019). However, in recent years, with enhanced opportunities for work and employment, voluntary migration from chars is also becoming fairly common. In our study, we found a significant proportion of migration among the young male/female members of char households, mainly as part of adjustments to riverine displacement and struggle to earn a better living. This is also corroborated by Salehin (1991), reporting that the displacement, which is physical, eventually leads to economic push. The present study finds that male migration is dominant compared to females in all study chars but on an average female migration accounts for around 30%, ranging from 26 to 36% in the study chars (see Fig. 18.2). A large percentage of male heads of households were found to migrate from the three study chars. It is important to note that they are identified as head by the household members, even in their absence as he earns for the family and controls the management remotely. Compared to other chars, the Meghna char residents have lower rates of migration through male HH heads and comparatively high migration by female HH heads. On the other hand, female migrants of Padma char constitute lowest percentage among all the study chars.

Migration is higher among the younger generation. Data presented in Table 18.2 show that large cities including the capital as well as small towns are popular destinations for the migrants. A significant number were found migrating to nearby villages. The reason could be that they want to be near their eroded land, so that in the event of this land reemerging in the future through accretion, they could claim its ownership before others came in to occupy the same. Besides, there are those who do not have the connection or financial means to make the initial move to distant towns and cities.

Malakandi char of the Meghna has the highest percentage of Male HH heads migrating abroad (over 15%), followed by those in the Padma char (Table 18.2). Comparatively higher literacy rate (56.3% at Haimchar Upazila) (BBS 2015) and better socioeconomic condition in Malakandi might have given them an edge over those in the other chars in this regard. Most of those going abroad prefer the Middle Eastern countries, followed by Malaysia.

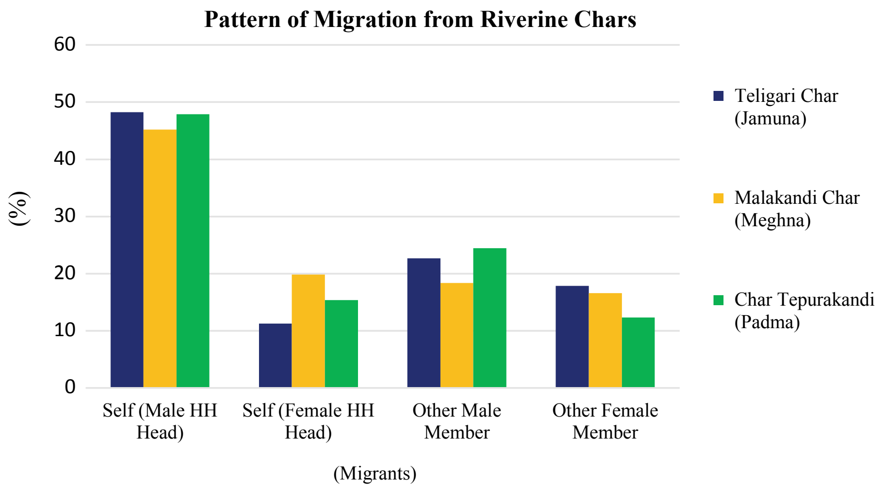

Fig. 18.2 Migration pattern of the study chars. *Source* Field Study (2019)

Table 18.2 Destination preferred by type of HH members (%)

Migrant	Nearby village	Small town	Big city/capital	Abroad
Teligari *Char* (Jamuna River)				
Self (Male HH Head)	23.25	25.25	45.64	5.86
Self (Female HH Head)	30.25	27.35	34.75	7.65
Other Male Member	35.25	31.13	19.36	14.26
Other Female Member	20.81	36.25	37.70	5.24
Malakandi *Char* (Meghna River)				
Self (Male HH Head)	20.78	24.46	38.98	15.78
Self (Female HH Head)	24.65	27.88	39.23	8.24
Other Male Member	34.76	26.15	25.65	13.44
Other Female Member	22.15	28.77	42.05	7.03
Char Tepurakandi (Padma River)				
Self (Male HH Head)	30.76	24.56	32.12	12.56
Self (Female HH Head)	38.28	25.66	29.3	6.76
Other Male Member	32.05	21.65	31.64	14.66
Other Female Member	33.56	24.35	33.54	8.55

Source Field Study (2019)

Studies on female migration in Bangladesh and findings from KIIs and FGDs of the current study reveal that distressed socioeconomic condition, accompanied by other social factors push females to migrate. Other studies had similar findings on female migration in Bangladesh (Ahsan 2005; Khatun 2004; Khatun and Khatun 2005). The female migrants initially move to nearby villages, then to relatively close small towns and gradually to the big cities.

Table 18.3 shows that migrants returning to the place of origin within 1 year is somewhat high among those from the Jamuna char. Propensity to stay as long as 5–10 years in the place of migration has been found to be the highest among HH heads in the Meghna char (39.14%). In general, female members have been found to spend relatively short shorter duration in the place of their migration, one exception being in the Jamuna char, where as high as 38.81% female HH heads stayed back for 5–10 years.

Factors Influencing Out Migration from Charlands

Migration due to natural disasters and inter-group social conflicts is common for the char dwellers (Islam and Khatun 2019). Natural disasters were reported to be the dominant causes for out-migration from the study chars, highest from Jamuna char, followed by the Meghna and Padma chars (Table 15.4). A significant number

Table 18.3 Extent of migration from the sample chars

Chars by types of HH Members (%Migrants)	<1 year	1–5 years	5–10 years	>10 years
Teligari Char (Jamuna River)31c				
Self (Male HH Head)	25.88	34.28	33.43	6.41
Self (Female HH Head)	25.76	28.56	38.81	6.87
Other Male Member	27.56	38.32	18.68	15.44
Other Female Member	26.19	33.49	28.93	11.39
Malakandi Char (Meghna River)				
Self (Male HH Head)	17.38	32.82	39.14	10.66
Self (Female HH Head)	18.92	32.62	37.28	11.18
Other Male Member	15.14	32.18	26.34	26.34
Other Female Member	20.11	27.44	28.02	24.43
Char Tepurakandi (Padma River)				
Self (Male HH Head)	20.18	37.13	25.24	17.45
Self (Female HH Head)	23.96	28.38	25.68	21.98
Other Male Member	8.01	43.87	28.45	19.67
Other Female Member	26.32	27.32	23.61	22.75

Source Field Study (2019)

Table 18.4 Reasons for migration

Reasons for migration	Teligari Char (Jamuna)	Malakandi Char (Meghna)	Char Tepurakandi (Padma)
	% of response	% of response	% of response
Natural disasters (flood, riverbank erosion, etc.)	54.28	47.56	36.12
Employment	27.28	27.35	38.57
Education	10.24	15.27	14.65
Social problems/conflicts	3.65	2.24	5.68
Marriage	4.55	7.58	4.98

Multiple answers were considered and the percentage is calculated with respect to the total responses
Source Field Study (2019)

of migrants reported better employment opportunity to be the reason for migration. Marriage is also reported as a reason for female migration (Table 18.4).

Over half of the respondents in Teligari relocated their houses 5–10 times. Displacement and migration caused by flood and erosion disasters are fairly common in the floodplain, resulting in loss of income and employment. During the FGDs and KIIs conducted by the current study, it was reported, particularly at Malakandi, that one-third of households faced dowry problem forcing heads of households to migrate to earn money for their daughters' marriage. This dowry is often used by the husband to finance his migration to some foreign land. As char areas have limited employment opportunities, people migrate in search of non-agricultural works, as reported by Ghosh (2018). Overseas migration can often be problematic in view of lack of information, unreliability of brokers and the rather complex process an aspiring migrant has to go through.

Migrants' Employments at Destination

The migrants are employed in diverse and multiple jobs—both full or part time, depending on availability of opportunities at the destination. The study reveals that employment in garment industries, available mostly for women, is considered attractive by the migrants (Table 18.5).

A majority of them are young and unmarried, spending almost all their earnings for the family with no or limited savings for themselves. However, respondents in Malakandi were found grateful to their hardworking daughters and were proud of their selfless girls. In some cases, they reportedly felt a bit ashamed to be dependent on daughters' income. A similar observation has been made by Islam and Khatun (2019). Sometimes, garment workers with similar char background are reported to form clusters of community in Dhaka and other cities (Das and Nahar 2018). Such networks play an important role in migration processes for the char dwellers.

Other economic activities at destinations include small business (maintaining tiny shops like tea stalls), rickshaw pulling and working as day laborers in the construction sector, etc.). Those who migrate to large cities prefer to get involved in the garment sector, rickshaw pulling, construction works, etc., and specifically ship breaking in

Table 18.5 Migrants' employments in the place of destination

Types of Involvement	Teligari Char	Malakandi Char	Char Tepurakandi
	% of respondents	% of respondents	% of respondents
Small business	46.81	57.89	9.8
Garment sector	89.36	95.38	35.29
Day laboring	51.06	63.16	56.86
Informal activities (salaried job, rickshaw pulling, sales work as hawker, ship breaking activities, work in transport sector, work in factories, etc.)	25.53	53.57	31.57
Construction activities (as mason, helper, etc.)	5.88	9.75	11.65

Multiple answers were considered and the percentage is calculated with respect to the total number of respondents

Source Field Study (2019)

Chattogram. However, poverty or low economic status of the migrants at Tepurakandi is reflected through their lower involvement in small business (<10%) and remarkably less involvement into garment sector. Due to stability of Char Tepurakandi compared to other two, the nature of migration and involvement in economic activities is different. Migrants from this char tend to work mostly as day laborers and in other informal activities in nearby villages/towns and were found less interested in migrating to areas of greater distance. Migrants from the chars are careful in sending money to their families. Mobile banking has been very popular among migrants. *Bkash* (money transfer through cell phone by using apps) is used quite commonly, while other mobile banking services are also in place.

Remittance Induced Development

Most of the migrants' earnest desire is to elevate their families' standard of living through the hard-earned income. Migrants' income is expended for diverse purposes (Table 18.6). Expenditure on household maintenance accounts for most of the remittance at Teligari (about 70%). Other family expenses such as medical treatment, education of family members and repayment of loan have also been reported. Expenditure on medical treatment is the highest at Teligari followed by Malakandi and Tepurakandi, indicating that the inhabitants of Teligari either suffer more from various diseases or have poor access to health services (WB, WFP and BBS 2009).

Expenditure on education is the highest at Malakandi followed by Teligari and Tepurakandi. It is worthwhile to mention that literacy level is the highest at Malakandi followed by Teligari and Tepurakandi. With support from some local individuals and public representative, free of cost boat service is provided to students at Malakandi for traveling to their educational institutions across the river since these are not available at the local level.

Repairing and maintenance of existing houses has been a priority for about 30% respondents of Teligari char, which is considered stable. In contrast, Malakandi is very unstable and people do not usually spend remittance for repairing houses rather they construct new houses in a safer place as an investment (preferably mainland on other bank of the river but not far from the char construction of new houses with all possible modern facilities in safer areas are commonly reported in all the study chars.

In terms of construction of houses, migrants of Malakandi are in the leading position (42%), followed by Teligari (34%) and Tepurakandi (22%). Construction of new houses gives them security and stability in life and enhances social status in the community. Spending money on children's marriage is a responsibility and again symbol of status in the society. Repayment of loan is common with remittance money. Another common use of the money is in livestock rearing and fattening. Traditionally women play an important role in taking care of livestock. Other uses of the money include availing sanitary toilets, safe drinking water, mobile phones, power connections, all of which help enhance quality of life.

Table 18.6 Use of remittance money

Use of remittance	Teligari Char (Jamuna)	Malakandi Char (Meghna)	Char Tepurakandi (Padma)
	% of respondents	% of respondents	% of respondents
Household expenditure	68.09	26.32	25.49
Medical treatment	17.02	10.53	9.80
Educational expenditure	31.91	36.84	19.61
Repairing house	29.79	0.00	5.88
Construction of house	34.04	42.11	21.57
Children's marriage	4.56	15.79	1.96
Repayment of loan	3.65	36.84	11.76
Investment in livestock	38.30	42.11	23.53
Investment in agriculture	59.57	15.79	15.69
Buying new lands	10.64	36.84	29.41
Savings	25.53	5.26	15.69
Buying boat	2.13	0.00	3.92
Business	2.13	10.53	0.00
Leasing in land	4.86	2.35	1.96
Buying farming equipment	7.89	1.84	1.96
Lending money for interest	3.58	2.86	1.96
Donating for community level infrastructure	3.15	2.01	1.23

Multiple answers were considered and the percentage is calculated with respect to the total number of respondents
Source Field Study (2019)

Migrant families also reported purchase of new lands/ boats/ farming implements and investment in small businesses. Migrants from Malakandi are involved more than those from the other chars in making investments in livestock, buying new land, business, etc. Teligari char dwellers invest more on agriculture, savings, leasing in land, purchasing farming equipment and money lending with interest. A part of the remittance is also donated to the local poor, particularly during crises and also for construction/ maintenance of mosques and *madrasas*. Through this engagement, solvent migrants uplift their social status and become more influential in the society at large. This often makes them eligible for membership in different management committees, thereby enabling them to participate in miscellaneous decision-making processes in the society.

Summary and Conclusions

Riverine chars are very different geographic contexts not just due to the dynamic nature of rivers with associated erosion-accretion processes, but also due to the prevalence of different sociocultural factors specific to chars (see Chap. 22). The three study chars are of no exception. Despite being physically vulnerable, char dwellers at Malakandi of the Meghna River have made remarkable positive changes in the standard of living compared to other two chars of the Padma and Jamuna through both domestic and international migration. Advanced level of awareness through comparatively high literacy rate has prepared them to take up challenges, develop good social network and optimum utilization of remittances. Location factor also facilitates them to utilize financial as well as social capital. Migrants from all study chars are drawn mostly from young energetic male members of the households. The remittance helps families of migrants on a day to day basis. However, emittances from abroad are also used for repair or construction of house and for business initiatives, which help elevate social position of the families concerned.

In the event of migration from chars, often resulting from erosion, the char dwellers find very limited institutional support. It would help individual households as well as char communities at large if proper guidance and support could be provided to them for domestic and overseas migration through a well-designed scheme. Besides, better planning in utilization of remittances coming from the migrants would help in longer term physical and socioeconomic development of the chars. Finally, given that char communities are so vulnerable to natural disasters, they need an effective disaster management program that can facilitate sustainable development for them.

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Chapter 19
Women in *Chars*: Challenges and Social Development Opportunities

Suzanne Hanchett

Abstract This paper reviews multiple issues of concern to women living in *chars*. The majority of *chars* women live with extreme poverty, social marginalization, low literacy rates, plus the need to cope with annual floods and displacement caused by periodic erosion events. Despite their social and economic disadvantages, women contribute significantly to the population's resilience in the face of crises. The impacts of large-scale interventions (economic, educational, health, domestic, and political participation) are discussed in terms of their impacts on women's lives. Challenges of service provision to island *chars* are daunting, but they can be overcome. Short-term, limited project interventions cannot solve problems at the required scale. Recommendations include putting women's issues at the center of any new human development strategies and developing approaches that respect women's dignity and strengths, rather than viewing them merely as "victims." Governmental institutions need to do more than they have thus far, giving priority to *chars* women's human rights and gender impacts of any future efforts must be carefully monitored, so that all can continue to learn from experience.

Keywords Women in *chars* · Poverty · Social marginalization · Lack of access to health and education · Human development strategies

Introduction

Women living in *chars* have numerous social and economic disadvantages that pose daunting challenges to the women themselves, and also to projects and programs designed to improve their situations. Women in *chars* are almost all poorly educated and poorly paid when they work outside the home. Their work options are more limited than men's, and they rarely find jobs using new technologies. Women farmers in *chars* receive fewer extension services than they need. They shoulder responsibility for the survival of their children under conditions that include near-starvation (*monga*)

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for a few months of every year and experiences of deep flooding and/or loss of homes to erosion. They are vulnerable to assault when violent conflicts break out. Compared to char men, they have less extensive friendship networks. Purdah standards and local social institutions strictly limit their access to public spaces such as rural markets. Women in *chars* rarely participate in public decision-making', and almost never in local dispute resolution sessions (s*alish*). The prevailing inheritance system is patrilineal, so their control of productive assets, especially land, is weak compared to men's. The widespread custom of giving dowry[1] makes them vulnerable to domestic violence. Social researchers have thoroughly discussed these concerns, most of which are common to poor rural women throughout Bangladesh (Islam 1995; Mahmud 1992).[2]

Their social disadvantages and other problems notwithstanding, women of *chars* are widely appreciated by researchers and social development practitioners for their coping strategies, their adaptive practices, and their social contributions. Mahjabeen Chowdhury (2001) and Doreen Indra (2000) both urge policy makers and practitioners to recognize that char women's indigenous skills, knowledge, and social formations are fundamental to family survival in this difficult environment (also, see Mondal 2012). They are seed preservers for the next round of cultivation. They do field labor, vegetable cultivation and preservation. They know which trees can thrive at different stages of char development. Ethnographic studies by Zaman (1988), Haque and Zaman (1989), Hanna Schmuck-Widman (1996), Doreen Indra, and Norman Buchignani (1997) have found that personal networks, including kin ties through women, often ensure family survival at times of post-erosion displacement.

This chapter is based on a literature review, supplemented by the author's own 1992–1993 research in *chars* of six districts as part of the rapid rural appraisal team conducting Flood Action Plan Study No. 16, or "FAP 16." (ISPAN 1995a, b, c, d, e, f, g). Our study found char women's roles to be especially flexible and broad, as compared to the normal roles of mainland women (ISPAN 1995a; Sarker et al. 2003). Other study reports also have remarked on this point (Hossain 2018; Chowdhury 2001, Government of Bangladesh et al. 2018b). Char women's normal duties also include earth-cutting and building up house plinths, to protect houses during annual floods. At times of crisis, such as erosion displacement, it has been observed that males and females may disregard customary role distinctions, as everyone pitches in to salvage belongings and relocate to safe spaces (see Fig. 19.1).

Natural disasters, such as erosion or deep floods forcing displacement, have multidimensional impacts. When people are harmed by such events, it is because adaptive arrangements and institutions often fail to support vulnerable groups (Oliver-Smith

[1] Dowry, a common practice throughout South Asia, is the giving of large cash payments and gifts from the bride's family to the groom and his family at the time of marriage. If there are disputes after marriage about amounts paid, or if a husband's family wants extra payments, a wife may be abused or held as a sort of hostage.

[2] Mahmuda Islam has thoroughly analyzed poor Bangladeshi rural women's political, social and economic issues, especially their unmet needs for technical training, extension services, and non-agricultural employment. Simeen Mahmud discusses the important but under-valued contributions of poor rural women to the economy, an issue of concern to rural women in *chars* and elsewhere.

Fig. 19.1 Abandoned house plot (on the left) due to fast approaching erosion. Women helping to rebuild house plinths to relocated new site. *Source* Suzanne Hanchett (1993)

1996, 1999; Ayeb-Karlsson et al. 2016). If char families are resilient enough to survive and thrive despite these crises, women deserve at least as much credit as men.

Some of the same issues challenging women in *chars* also confront women in other disaster-prone regions, such as the southern Bangladesh coastal belt, which is frequently hit by cyclones. Hasna Hena, discussing the 1991 cyclone, argues, for example, that there was (and is) a tendency in the media and among policy makers to reinforce stereotypes of women as "weak, vulnerable and subordinate,"… "ignoring the women who dug graves and who tried to erect their homes again," denying any "projection of a woman's power and strength." (Hena 1992: 67–68, 73).[3]

Women's Vulnerabilities at Times of Deep Flooding

Two social surveys, one by Azad et al. (2013) and another by Shakibul Islam (2017), have summarized the details of women's experiences with deep flooding in Sirajganj and Rangpur districts, respectively. The study by Azad et al. (2013) includes flood-affected populations of non-char areas along with Jamuna char dwellers while Islam (2017) focuses entirely on char villages. These two studies compared four types of "vulnerability" of women during floods, as shown in Table 19.1. These statistical reports show clearly the broad extent of annual hunger, damage to productive assets, health risks, and other extreme difficulties that women must cope with every year during deep floods. Comparing the two studies, it is interesting to note that Islam's

[3] Khushi Kabir and Farida Akhter—two NGO leaders also writing about the 1991 cyclone experience—spoke out about female relief workers—even Khushi Kabir herself, the executive director of Nijera Kori, a national NGO—being prevented from traveling to affected areas because their "security" could not be assured. (Akhter 1992: 59, Kabir 1992: 78). Also, see Zaman (1999), which uses similar categories to analyze household experiences of seasonal "disasters."

Table 19.1 Women's vulnerabilities in flood crises'

Specific vulnerabilities	Azad et al.[a] (%)	Islam[b] (%)		Azad et al.	Islam (%)
Human			*Structural*		
Malnutrition	91	80	Damaged roads and other infrastructure	99%	100
Diseases	85	100	Damaged latrines	–	95
Food shortages	89	99	Lack of safe drinking water	84%	78
Physical injuries	25	85			
Managing menstruation	47	30			
Social			*Agricultural*		
Lack of clothing	89	62	Damage to productive assets: – Crops	25%	100
Finding fuel wood	84	100	– Homestead gardens	75%	51
Unemployment	64	75	– Cattle	65%	58
Harassment	35	60	– Poultry	71%	54
Crime	16	5			

[a]Women's direct reports on their flood experiences, Jamuna char and non-char areas of Sirajganj District combined
[b]Questionnaire respondents' opinions on which types of flood-related problems make women vulnerable in Char Gonai, Rangpur District (in the Teesta River)

study, based entirely in a char area, finds a much higher incidence of women's injury and harassment at times of flood crisis.

Promoting *Char* Women's Rights and Improving Livelihoods

Programs and projects to improve *char* dwellers' livelihoods and adaptive capacities have expanded and evolved during the past 50 years. Hundreds of local, national, and international NGOs, more than 10 international aid organizations, and several Bangladesh government departments have tested a wide range of social development approaches. The largest social development projects working in *chars* to date are discussed in detail elsewhere in this book (see four case studies in Chaps. 20 through 22). Other than the four case studies, *Nuton Jibon*, formerly Social Improvement

Program Project (SIPP), implemented in 16 districts with both char and non-char populations, has been a major intervention.

Typically, any "sustainable livelihoods" approach—with its vision of holistic service provision and bottom-up development—underlies most social development interventions offering multiple, combined social, economic, and political empowerment opportunities to very poor households. (See Chambers and Conway 1991; Scoones 1998; De Haan 2012) This approach is logical and appropriate because of the many ways that different types of issues affect each other. Social development programs and projects inspired by the livelihoods approach vision of change have tinkered with all levels of char society, including village-level institutions, domestic life, and control over productive assets. These efforts are part of an ongoing learning process. Results of intervention efforts have been carefully documented. Impacts are carefully analyzed by evaluation researchers. Sustainability of positive changes is still an open question, however. Women's issues are gradually getting attention. Projects and programmes support women's rights in the economic, education, health, domestic, and public spheres.

Improving Economic Security

According to Pandey (2015: 219), the poverty rate in *chars* is 80%, much higher than the Bangladesh national average of 30%. Economic insecurity is a major cause of char dwellers' vulnerability, so almost all programmes and projects give substantial attention to improving livelihoods, especially increasing women's access to financial capital, markets, and job-related training. Livelihood supports from char development projects and programmes take many forms, as other papers in this volume demonstrate. These range from job skills training, to donation of assets (cattle, goats, poultry, land, tools), giving cash grants, formation of savings groups, and multiple interventions in various combinations depending on programme guidelines and resources. Participation in income generating activities has been proven statistically to directly benefit women's over-all status and situation, according to the livelihood approach's five types of "capital" (Al-Amin et al. 2011).

CDSP has helped to secure women's legal rights to redistributed government lands by making sure that their names are entered along with their husbands' names onto registered land titles. Considering the importance of land rights, patrilineal inheritance, and the violent competition over land in *chars*, this is one of the most dramatic and potentially transformative measures ever undertaken by a human development project (also, see Chap. 22). Two simple points relating to women's economic interests deserve emphasis. First, some char women are farmers with full responsibility for cultivating family lands. In some regions they even plow the land, a strictly male job in the rest of Bangladesh. (Hossain 2018; Chowdhury 2001; ISPAN 1995a; Government of Bangladesh et al. 2018b) Like rural women elsewhere, their agricultural duties and their needs for extension services and veterinary care are not adequately attended by the respective government departments. Secondly, women in *chars* need to earn money and access credit as much as men do. Pervasive food insecurity is a common problem, as crops and livestock are not always available during the annual flood season. Food prices rise steeply during floods. Food supply is of special concern to women, as virtually all women's social responsibilities include care for homestead gardens, livestock, and poultry—those resources that fend off starvation for much of the year.

One learning point from large projects has been the importance of savings. Savings groups created by char development projects have been, especially popular among women. According to one evaluation study, savings and loan groups formed by CLP have continued on their own after the end of project support, serving as effective "[vehicles] of social change and collective action," especially for women.[4] (Jasper et al. 2016: 20) Micro-credit is also part of many programs, though high-interest NGO loans are known to aggravate hardships already faced by the ultra-poor. In some CDSP areas, for example, recipients of government land grants have been forced to sell their lands to pay off such loans. (Government of Bangladesh et al. 2012)

Access to markets is a serious obstacle to women's economic advancement because of purdah norms. The ethnographer Hanna Schmuck observed in her study of char life in Tangail District that, "Going to market is a male preserve." Mahjabeen Chowdhury (2001: 10) found in Gaibandha District that widows and women without male "guardians" were forced to do their own marketing, but "shame" prevented them from visiting regional markets. So they usually waited for wholesale traders to come to their doors. Such constraints explain the CLP evaluation study finding that women engaged in project-based production generally prefer to use smaller, local markets for marketing their products rather than the larger mainland markets. (Jasper et al. 2016) As Islam (1996) and others have pointed out, group approaches to economic capacity building—rather than approaches focused only on individual producers or business owners—can work for poor rural women in Bangladesh under certain circumstances. Savings groups are a good example of this type of approach.

Educational Deficits and Schooling for Girls

Literacy rates in char populations are still low: 25.3% versus the national rate of 51.3% (Pandey 2015). This situation limits both women's and men's non-agricultural employment options. There are primary schools in many *chars* but not enough teachers. One study found that trained teachers posted to island *chars* often send proxies to teach for them, because they do not want to live in these difficult environments (Aminuzzaman 2001). During floods and storms, traveling to schools can be hazardous, so parents may keep their children at home. And, even if children finish primary schooling, opportunities for secondary education are quite limited.

[4] This is not true of "Village Development Committees," which mostly stopped meeting when project support ended (Haneef et al. 2014).

In 1994, the Government of Bangladesh began giving cash subsidies and food to rural, school-going girls. This Female Stipend Program has helped to keep some char-dwelling girls in school beyond the fourth or fifth standard, when they customarily would be taken out of school and married. According to Shireen Akhter,[5] girls of families that participated in CDSP-IV did study as far as class 9 or 10 in order to access program benefits, but boys typically were not kept in school. And when the girls married, their husbands tended to be less well educated than they were.

Domestic Life

Women's status and other issues are discussed and analyzed in "awareness-raising" sessions, which are especially common in NGO-facilitated programs. CLP supported husband-wife discussion sessions. CLP also encouraged its newly formed Village Development Councils to give priority to combating the interrelated phenomena of early marriage, harmful dowry demands, and violence against women (Haneef et al. 2014). According to an ethnographic study report carried out in a Jamuna char in Gaibandha District (Hossain 2018), marriage of girls at age 14 or 15 of age) is justified locally by the custom of requiring lower dowry payments for younger daughters' marriages. Hossain learned that marrying off an older daughter requires a payment of Tk. 200,000, while dowry for a younger one is only Tk. 50,000. Another study (Jasper et al. 2016) reported that dowry payments often increase as family income improves.

In many project-based groups, social development practitioners speak out against arranging early marriage, which is illegal. Or they try to intervene in cases of domestic violence. In any event, solving such problems will require more than help from outsiders offering short-term project interventions. Internally, initiated social changes would be necessary. More than one evaluation study has found that domestic violence tends to decline on its own as women's earning capacity and resource control increase. According to the 2012 CDSP-III Impact Evaluation Study, 85% of women had experienced family level "tortures" or violence at the hands of relatives, robbers, land-grabbers, or pirates. This source claimed that the rate had come down to 40% due to NGO orientation, community mobilization, improved law and order, and the system of husbands and wives" jointly owning agricultural land (Government of Bangladesh et al. 2012). A CLP-II evaluation study found domestic violence still to be a problem but heard people in all areas saying it had decreased because (a) the generally better economic position of households made for less tension, and (b) women's contributions' to household income and control of productive assets increased (Jasper et al. 2016).

Merely having a program or project seems to create self-consciousness and discourage abuse of women. In one CLP evaluation study focus group discussion, for example, it came out that local men feared project sanctions if they mistreated their

[5] July 2019, personal communication.

wives (McIntosh et al. 2012). Another CLP evaluation study found that, “Although some male respondents felt that some form of physical violence was necessary in a marriage, on the whole it was not widely accepted.” (Haneef, Kenward et al. 2014)

Char Women’s Health Risks and Service Needs

Annual deep floods and erosion-induced displacement not only challenge local society; they also create public health problems. Our 1992–93 ISPAN, rapid appraisal study of char communities and other research studies have found that the normal monsoon period is considered to be a dangerous time. Diarrheal diseases associated with poor sanitation and difficulties with access to safe water supplies were said to have caused more deaths than extreme floods or erosion did (Sarker et al. 2003). Shakibul Islam’s study in Rangpur District found outbreaks of viral and fungal infections to be most prevalent during the flood season, largely because of damaged sanitation facilities and unavailability of clean drinking water. Injuries also are a health issue’. Furthermore, this study refers to reports from local healthcare workers of “increasing trends of gynecological problems due to unhygienic water use” at times of waterlogging. (Islam 2017: 212) Women interviewed by the FAP 16 study team in 1992–1993 mentioned being often afflicted with specific illnesses (called *sutika* and *ghaa*)[6] during the monsoon season. Azad, Hossain, and Nasreen’s 2011 survey in Sirajganj District also found injuries (25%) and water-borne illnesses (85%) to have afflicted women during floods. Not having enough money hindered their ability to get needed medical care’:

> Because of their physical injuries during and after floods, women could not work properly but had to cook and perform daily activities despite sickness or injuries. They hardly ever were able to get treatment due to lack of money. Although these problems were not unique to women, females seemed to be the worst hit and these disadvantages imposed additional difficulties in their subsequent ability to cope with adverse circumstances (Azad et al. 2013: 195)

Pregnancy and birth, risky processes even under ideal circumstances, can be life-threatening in *chars*. We heard multiple complaints in island *chars* about health care being delayed because it was impossible to travel to mainland clinics or hospitals during floods and storms. Risk is especially serious at times of Pregnancy. (ISPAN 1995b). Recent research studies in multiple char regions also have found maternal mortality to be associated with inadequate perinatal care, especially during the monsoon season. For instance, no facilities were available in the southern char region prior to CDSP-IV, and as a result families suffered from a wide range of health problems, including significant maternal and neo-natal mortality. (Government of Bangladesh et al. 2018b) Yasmin and Ahmed (2013) found maternal mortality

[6] *Ghaa* symptoms are painful sores on the feet, caused by standing in water for long periods of time and making it very difficult to walk. (ISPAN 1995d, pp. 9-2)*Sutika/shutika* is post-partum diarrhea and anemia considered to be life-threatening. (Blanchet 1984)

to be an important problem in their 2012 study of disaster coping in the Padma River's Patgram Char (Manikganj District), because women lacked access to hospitals, and local clinics were limited or nonexistent. Our 1992–1993 study found that government health and family planning workers did visit island *chars*, offering immunizations, contraceptive pills, etc., but there was no consistent service pattern.

Both CLP and CDSP—the two largest donor-funded char development projects—devised ways to fill some of the gaps in healthcare for women and others. CDSP supported the establishment of NGO-managed mobile clinics in or near southern coastal belt *chars* and has provided training and support to health and family planning facilitators and traditional birth attendants. The new healthcare facilities were found to be greatly appreciated by focus group participants interviewed during an evaluation study of CDSP-IV (Government of Bangladesh et al. 2018b: 31). The CLP also moved in the direction of bringing health services to island char populations. Local people were trained as community health workers and paramedics through the project (CLP 2016). The use of latrines replaced open defecation in almost all regions covered by projects and programmes, according to recent reports, and tube well water is more available than it was in the past.

Participation in Public Life

CLP evaluation studies found that generally positive socio-political changes resulted from project interventions, as poor people gained the respect of the community and managed to improve their linkages with local government (union *parishads*) and NGOs. (Haneef et al. 2014) Fostering such linkages can support women's empowerment in both small and large ways. An evaluation of CLP-II found char project participants, both men and women, making better use of union services, such as birth and marriage registration, than before the project. Perhaps, more importantly, union councils were found to give poor people associated with the project more "respect and consideration." Char people influenced by the project are registered as voters and have been found to be "actively pursuing their own demands." (Jasper et al. 2016: 56–59)

CDSP has given careful attention to improving both male and female char dwellers' access to the services of multiple government departments, such as, BWDB/Water Board, Forestry, DAE/Agricultural Extension, and DPHE/Public Health Engineering. It has done this by building connections between these agencies and project groups who need help with technical matters, as discussed elsewhere in this volume. It is significant that three of the 24 char women profiled in a 2018 CDSP-IV Gender Impact Assessment had stood for, or were planning to contest election to union council (union *parishad*) seats. Case studies of those standing for election show that project interventions such as CDSP can support women who wish to assume leadership roles in their communities. Water Management Groups clearly were encouraged in CDSP to take action beyond their technical roles and move into the sphere of broader local decision-making.

Some social development efforts in *chars* have created entirely new local institutions, partly in order to counteract the influence of male-dominated *samaj* and *salish* institutions normally in charge of village-level governance and dispute resolution. The World Bank funded project, *Nuton Jibon*/SIPP, for example, created and supported a new system of village- and inter-village councils.[7] The World Bank claims that, "Ninety-five percent of SIPP-II beneficiaries are women who also occupy most decision-making positions in community institutions." (World Bank 2015) One NGO, Udayan Swabolombee Sangstha (USS), implementing social development programs in Jamuna char settlements of Gaibandha District in the early 2000s, set up a system of elected women's councils (*Gram Unnayan Parishads*/GUP, or 'village development councils') that conducted dispute resolution sessions, duplicating and challenging the influence of customarily male-only groups (*salishes*). GUPs also managed group savings and did general awareness-raising on water, sanitation, and other local issues.

An assessment of the CARE program known as Strengthening Household Ability to Respond to Development Opportunity (SHOUHARDO) found that involvement' in various program interventions improved levels of women's participation in' all sorts of decision-making, including *salish*, from the baseline 10–40% (Nosbach 2014). Externally imposed changes in local institutions do not always survive the ends of their sponsoring projects; nor are they 100% effective. Nonetheless, through such efforts many individuals, both women and men, have improved their access to needed services and formed new political connections. People seeking broader roles in community or regional decision-making have also found leadership opportunities through projects and programmes.

Female Household Heads

The female-headed household (12–15% of the nationwide total) is a subject of interest and frustration among human development practitioners. Char society reportedly has larger percentages of female-headed households than other rural populations. According to Raymond Wiest (1991), for example, island *chars* and embankment settlements have almost three times as many female-headed households as mainland communities. An evaluation study of CLP-II found female household heads generally less able to benefit from the project's interventions than other women (Jasper et al. 2016), so this category of women deserves special attention in planning for *char*s.

Female-headed households exist for various reasons: male migration, abandonment, divorce, separation, or widowhood. In his 1985–1986 study of three char regions—two in Chilmari and Kazipur along the Jamuna River, and one in Bhola District—Wiest (1991) found that 68% of female household heads were married (husbands working elsewhere), and 32% were widowed, abandoned, or separated.

[7] This village-government system and other Nuton Jibon programs are now overseen by a quasi-governmental entity, the Social Development Foundation.

Having no adult male in a household tends to create obstacles to livelihood security and participation in public life (Hossain 2018). Purdah norms and patriarchy are the principal reasons for this problem. In West Bengal *chars* within India, Kuntala Lahiri-Dutt and Gopa Samanta found the widows and abandoned women—"de jure heads"—to be especially poor because of their high dependency ratio and the absence of earning male household members: "Their poverty also affects their ability to provide for adequate self-protection; as a result, they are less able to create safe conditions during floods and riverbank erosion." (Lahiri-Dutt and Samanta 2013: 194) Like female household heads in Bangladesh *chars*, these particularly disadvantaged char dwellers depend almost entirely on personal connections to survive: "Network support and the social capital of kinship relations are the chief mechanisms that women-headed households use to mobilize resources and cope with contingencies." (Lahiri-Dutt and Samanta 2013: 194) Being the most destitute members of already ultra-poor groups, char-dwelling women without husbands or adult sons need fruitful employment. Several governmental and non-governmental programs have found them willing to join work crews repairing roads and doing other hard manual labor.

Women's Own Comments About Their Development Needs

Women have expressed themselves as participants in social surveys, as focus group participants, and by communicating with ethnographers. Md. Altaf Hossain heard positive comments from some women in his Jamuna River ethnographic research site about how NGO programs and CLP had made at least incremental improvements in their economic situations. A female participant in a CLP-formed cooperative with a savings program commented in an NGO-facilitated group discussion, "We cannot cultivate crops without receiving money from the moneylenders. If we get credit from our business committee [co-op], then we will not be at the mercy of the moneylenders anymore" (Hossain 2018: 204).

CLP and CDSP evaluation researchers have heard directly from female project participants in focus group discussions and have published some of their comments. These published comments have been generally positive. A CDSP-IV Gender Impact Assessment claims that because of project interventions, "Now men are also aware about women's rights. Generally they have stopped passing unfavorable comments about women's activities." (Government of Bangladesh et al. 2018b: 13) Some FGD participants who had "graduated" from CLP remarked that husbands now respect their wives' opinions more than they did before the project (McIntosh et al. 2012).

In 2015 the First Char Convention in Dhaka offered a new venue for women's voices to be heard. A number of char-dwelling women spoke to a general audience about their problems at this event. Their comments show that the job of improving life for women in *chars* is not finished, despite the many social development efforts launched in recent decades. A Rajshahi District char-dwelling woman, for example, spoke directly about the multiple problems she and others face and urged public officials to provide desperately needed services:

> In the open floor session... Nasrin Akhtar from Rajshahi, alluding to the deprivation of the *char* dwellers asked, "Are we human?" She said that they are devoid of every right. There is no good teacher to get proper education and the health provisions are poor. Flood [damages] their crops while local goons torment them continually. She said that without improving the condition of health and education, and removing the goons, their fate will not change. (First National Char Convention 2015: 254).

Concluding Remarks

This overview and the researchers mentioned above have made specific recommendations that supplement the general insights gained from project evaluation studies and others. Azad, Hossain, and Nasreen recommend improving legal supports to women, enforcing laws against early marriage, combatting violence against women, and expanding women's access to employment and markets (Azad et al. 2013). John Rogge and other researchers in Jahangirnagar University's Riverbank Erosion Impact Study argue for more emphasis on human development, self-organization, and improved extension services. Mahmuda Islam's recommendation that agricultural extension services' be provided to all farmers, whether they actually own the land they work or not, applies directly to women in *chars* (Islam 1996). Rogge and Islam both recommend creating safe spaces for women in emergency shelters (Rogge 1991; Islam 2017). One recommendation that came out of the ISPAN study was to improve and expand basic health and sanitation services to char populations. (Sarker et al. 2003; EGIS 2000) Challenges of service provision to island *chars* are daunting, but they can be overcome. Bankline or attached char settlements have relatively easy access to clinics and hospitals if there are roads passable during storms and floods. Island settlements, however, require more creative and expensive arrangements, such as mobile clinics.

Some government departments have drafted gender equity policies, but follow-up and implementation reportedly are less than satisfactory in most agencies (Government of Bangladesh et al. 2012). If and when large-scale empowerment of women in *chars* becomes a genuine governmental priority, all activities and programmes must be carefully monitored. Gender impacts must be routinely assessed in a transparent manner, so that mistakes can be corrected and all can continue to learn from experience.

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Part VI
Case Studies on Major Experiments in Char Development

Editors' Note

Part VI presents four case studies on experiments in char development in Bangladesh.

Lokman Hossain provides an overview of the Chars Livelihoods Program (CLP). The CLP was initiated in 2004 with the objective of providing support to the extreme poor households in the northwest island chars in the Teesta-Brahmaputra-Jamuna area. CLP took a holistic approach to char development through eight major interventions. With more than twenty different projects, CLP supported 133,026 extreme-poor households in ten districts through eighteen partner NGOs. Considered a highly successful program, the CLP offers useful learning experiences for future work in reducing poverty in remote char areas.

Nazmul Chowdhury reports on the success of sandbar agriculture, an experiment for cultivation in low-lying transitional char lands that appear and disappear in the floodplains every year. These new charlands can be used only during the dry/winter season when the water level is low for four to six months. The sandbar cropping project was initiated by Practical Action (PA) through a series of action research drives over a period of five years (2005–2009) in Gaibandha District.

Koen de Wilde analyzes the Char Development and Settlement Project (CDSP), jointly funded by the GOB, IFAD, and the Government of the Netherlands to resettle erosion displaced households in the coastal char regions. The new charlands, once stabilized, are settled by pre-selected landless households, with land rights/titles and other internal infrastructure support. The work by CDSP, with support from various government departments and NGOs, has led to considerable socio-economic benefits to a large number of households in coastal char areas within Bangladesh.

The Danida livelihood development programs as described by Harvey Demaine took off from the CDSP experience. Harvey Demaine describes how char settlers in coastal areas gradually shifted their livelihood sources from livestock and fishery development to different forms of animal husbandry and to aquaculture in place of fishery. The main focus was to develop a sustainable extension approach, including the establishment of Farmers Field School, toward generating improved livelihood options for poor rural households through their involvement in the fisheries and livestock sectors.

The experiments above surely have valuable lessons to be used in formulation and execution of a holistic approach toward overall char development in Bangladesh.

Chapter 20
The Chars Livelihoods Programme: Experiences and Learnings

Muhammad Lokman Hossain

Abstract The Chars Livelihoods Programme (CLP) was initiated in 2004 with the objective of providing support to the extreme poor families in the northwest island chars of Bangladesh and carried out its activities in two consecutive phases: Phase one: 2004–2010 and Phase two: 2010–2016. Chars are formed from silt deposits and are prone to erosion and flooding. Char dwellers face many obstacles, including limited livelihood options and are heavily reliant on selling their physical labour. Like other parts of rural Bangladesh, people from chars temporarily migrate to urban areas in search of work, especially during the lean season. Health care and educational facilities in the chars are very limited and rather poorly resourced. Farmers often suffer from limited availability of agricultural inputs like seeds, fertilizers, insecticides, implements, fuel and feed for their livestock. Households wishing to sell miscellaneous items like vegetables, milk, chicken and duck are constrained by their remoteness to markets that are usually at a fair distance from their villages. With more than twenty different projects, CLP supported 133,026 extreme poor families in ten districts through eighteen partner NGOs. The programme achieved a good deal of success and generated useful learning experience for future work in reducing poverty in such remote areas in Bangladesh.

Keywords Char livelihoods · Poverty reduction · Food security · New economic opportunities · Empowerment of women · Resilience to risks · Social and organizational leadership development

The Context and Background

In Bangladesh, chars have historically been formed by silt deposits within its many rivers. Prone to erosion and flooding, these land masses are not easy to live in. However, in recent decades, due to the country's population density and concomitant shortage of land, these have become permanent home to hundreds of thousands of people of the country, many of whom are extremely poor. They are faced with

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numerous obstacles, like limited livelihood options, heavy reliance on selling own labour, inadequate communication and basic services from public institutions, etc. Like other parts of rural Bangladesh, demand for labour in chars fluctuates throughout the year and people temporarily migrate to cities in search of work during the lean period.

Basic services, such as schools and community health clinics are poorly resourced in the chars. Farmers suffer from limited availability of agricultural inputs like seeds, fertilizers, insecticides, machineries, fuel, ready feed for cattle and other livestock. Families wishing to sell their products, such as milk, meat and vegetables are constrained by their remoteness to markets, which are mostly a fair distance from their villages. Besides, there is only limited involvement of government or non-government agencies there. There, however, is significant potential in chars, as has been demonstrated by the Chars Livelihoods Programme (CLP).

Chars Livelihoods Programme: The Journey

Originally submitted as a project proposal for livestock development to the Department for International Development, Bangladesh (DFID-B) in the late 1990s by three NGOs, Rangpur Dinajpur Rural Services (RDRS), *Gono Unnayan Kendra* (GUK) and *Manob Mukti Songstha* (MMS), CLP-1 was designed and began in 2004 as a programme for the char people. It took a holistic, yet intensive approach towards reduction of extreme poverty, focused on improving overall welfare of the concerned households during 2004–2010.

CLP-1 had several design and implementation mechanisms, and with limited progress in implementation, a significant redesigning of the programme was needed and undertaken in 2005. Working in a remote, institutionally weak and environmentally volatile region was challenging and needed careful consideration of what the right entry points were, and how to balance processes and methodologies. Alternative methodologies were considered; many were tried, some adopted and some rejected. Given early experience, CLP-1 focused on simplifying processes to ensure goods and services were delivered directly to the extreme poor households[1] while placing strong emphasis on ensuring quality delivery and carefully examining the impact evidence mainly to adjust delivery processes. Over time, CLP-1 created a model which reduced extreme poverty in a location where other development agencies and programmes had not reached at that time. The centre piece of CLP-1's approach was

[1] Households living under the extreme poverty line, as defined by DFID-B, represent the poorest 10% of the population. Jackson (2009), using inflation adjusted 2005 Bangladesh Bureau of Statistics Household Income and Expenditure Survey (BBS HIES) data, calculates this to be those households living on less than Tk.22 per capita per day at the national level and for Rajshahi Division, covering the CLP1 working area, Tk. 18 per capita per day. However, it should be noted that although CLP1 focused on the poorest 10%, in the char areas this does not mean only 10% of the population was targeted. It is estimated that, on average, 30% of households across CLP1's working area were qualified for the programme.

the ‘transfer of productive assets’ to the extreme poor households through selected Core Participant Households (CPHHs), which was continued throughout the phase of CLP-2.

Like Phase-1, CLP in its second phase during 2010–2016 aimed to help underprivileged and extreme poor families living in the northwest riverine island chars in Bangladesh. With over twenty different projects/ interventions focusing on areas ranging from infrastructure to food security and hygiene, CLP was large and complex in its scope and ambition. Eighteen NGOs, called Implementing Organizations (IMOs), provided CLP’s holistic package of support to the extreme poor families in 10 northern districts of Bangladesh. In two phases, CLP supported 133,026 families through 10 separate and annual intake groups called ‘Cohorts’.[2]

CLP was jointly funded by UK Aid through the Department for International Development (DFID) and the Australian Government through the Department of Foreign Affairs and Trade (DFAT), sponsored by the Ministry of Local Government, Rural Development and Cooperatives (MoLRD&C), Government of Bangladesh (GoB) and implemented by Maxwell Stamp PLC (MSP), a UK-based international management and consulting firm.

Background and Profiles of the Participants

The concept of participatory wealth ranking by the community has dominated thinking about identifying poor households in poverty reduction programmes. CLP decided not to adopt a formal wealth ranking because of the costs involved (in terms of time and skilled resources) and risks of biases for benefitting individual with superior social status. Instead CLP chose to use a set of objective criteria: ‘assetless,[3] landless, jobless’ and several supporting criteria (see Pritchard et al. 2016) as shown below. All households meeting the criteria in a village were selected as CPHHs; an average of 30% and reaching more than 50% in some villages. Those covered had the following profiles: (i) limited cash savings—each family had less than Taka 400 in cash savings; (ii) limited productive assets—each family had productive assets worth less than Tk 5000; (iii) food insecurity—over 70% of families did not have the resources to eat 3 meals a day; (iv) heavily reliant on wage labour—67 to 91% of a family’s income came from wage labour; (v) poor hygienic practices—before CLP, 74–78% of families did not have soap/ash at key water points or near their latrines; (vi) no access to sanitary latrine—less than 8% of families had access to a sanitary latrine; and (vii) over 95% of families collected drinking and cooking water from

[2] A group of households coming from the same asset transfer cycle (i.e. from the same 18-month period).

[3] CLP1 defined “assetless” household as those owning productive assets worth less than BDT.5,000 and landless to mean those owning absolutely no land, homestead or agricultural. Other selection criteria included joblessness, no outstanding loans from microcredit institutions, not being a recipient of benefit from other grant or credit-based programme and length of residency in their respective villages.

unsafe sources. In sum, by and large, families selected for CLP programmes were generally poor and belonged to the lower stratum of the char villages.

CLP Approach

The centre piece of CLP's approach was the Asset Transfer Programme (ATP). It meant the transfer of productive or income-generating assets (mostly cattle/ cow) to the extreme poor households as per their choice in both the phases. ATP was based on a similar mechanism to that implemented by Bangladesh Rural Advancement Committee—BRAC's Challenging the Frontiers of Poverty Reduction (CFPR) programme. These assets were transferred to a total of 133,026 extreme poor households (Phase-1: 55,000, Phase-2: 78,026) through a core participant from each household. They were viewed as central participants in the development process and targeted through applying the criterion of being able to attend weekly social discussion meetings. This transfer was supplemented with a monthly household cash stipend for 18 months to support household consumption and the cost of undertaking their income-generating activities—for instance, rearing cattle. It was observed that around 98% participants chose cattle while 1.75% chose land and the rest chose other things as an asset (see section on asset transfer and stipend).

In addition, core participating households were supported by a range of complementary interventions. These included annual employment opportunities for up to 50 days on public works during *monga*[4] or the provision of cash safety-net support if no household member was able to work; inputs and training to engage in livelihood activities, such as homestead gardening; and support for the development of social capital through group formation, and an 18-month curriculum of social awareness raising and capacity building, etc. In addition, core participant households were prioritized for work opportunities on a cash for work programme, raising homesteads above the highest known flood level for flood proofing (see Chap. 15). The sequencing of these interventions was specifically timed to either meet the seasonal needs of households or to build layers of mutually re-enforcing interventions.

The theory of change and social transformation by CLP was that through the Asset Transfer Programme (ATP), participation in weekly social development meetings and connection with the mainstream market system, extremely poor households could build up assets (economic, human and social) to generate reliable income and carve a pathway out of poverty (see Fig. 20.1) The expectation was that not only would livelihoods of the core beneficiary households be protected and promoted, they would be transformed, allowing households to have sustainable and self-sufficient livelihoods.

[4] *Monga* is a Bengali local term, meaning seasonal hunger or food insecurity. It usually happens between mid-September to November in ecologically vulnerable and economically weak parts of north-western Bangladesh, primarily caused by an employment and income deficit after the Aman rice crop is transplanted and before it is harvested.

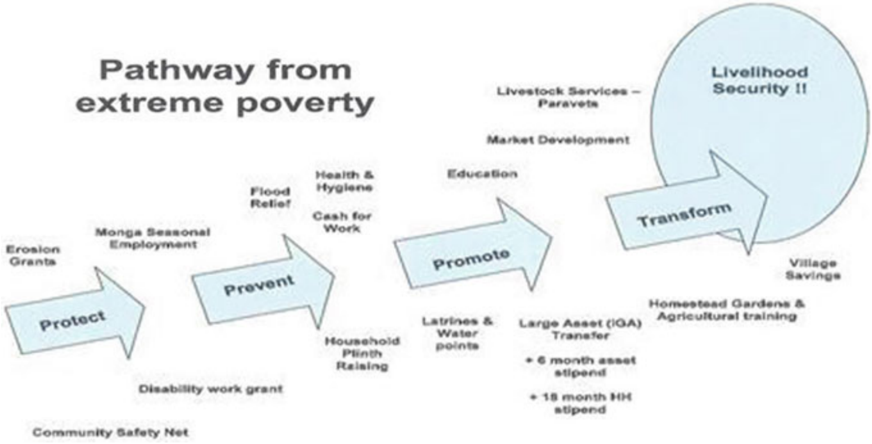

Fig. 20.1 CLP's pathway out of extreme poverty to livelihood security. *Source* Conroy et al. (2010)

Major Interventions Under CLP

The CLP undertook the following eight major interventions under both phases: (i) asset transfer and stipend; (ii) livelihoods training and support; (iii) social awareness raising and development; (iv) flood protection and employment generation; (v) water, sanitation and hygiene (WASH); (vi) health and nutrition services; (vii) formation of community-based organizations; and (viii) market/private sector development. These are briefly discussed in the following.

Asset Transfer and Stipend

Asset transfer and stipend was the heart of all CLP's activities aimed at improving livelihoods of the poor char dwellers. The aim of the asset transfer was to diversify the income sources of the CLP-supported households in order to make families more resilient in times of economic, environmental and health shocks and disaster. It also offered a foundation from which participants could accumulate more productive assets by, for example, breeding their heifer for calves to sell or rear. Asset transfer intervention allowed 133,026 female participants to purchase an income-generating asset of their choice with the grant, the value of which increased due to inflation from Taka 13,000 in 2006 to Taka 17,500 in 2014. It was observed that around 98% participants chose cattle while 1.75% chose land and the rest chose other things as an asset. To help with initial costs associated with rearing livestock such as cattle feed, CLP provided these families with a monthly asset maintenance grant for six months. In addition, each family received a small monthly stipend for eighteen months in order to cover general family subsistence/ maintenance cost.

Social Awareness Raising and Development

Dowry and early marriage permeated all through societies on the chars, despite being illegal and a detriment to development. Prior to CLP, families on the chars often lacked the knowledge and understanding of such issues, and these types of practices were deeply engrained in culture. Increasing awareness and changing such longstanding social norms were challenging and time-consuming tasks. To support this process of change, CLP formed Social Development Groups (SDGs) with CPHHs, who attended weekly group meetings in their village for 18 months. Here, they learned about issues such as early marriage, dowry, women empowerment, improved water, sanitation and hygiene practices, family planning options, health and nutrition issues, savings and loan management and disaster preparedness.

If married, CLP's female participants also attended a one-day marriage counselling session with their husbands. Together, they received gender-sensitivity training that was intended to empower both partners by encouraging joint decision-making within the household and discouraging destructive attitude like spousal violence. The couples came out of their training with greater mutual respect. This social development activity was also a main platform for fostering women's empowerment on the chars at household level. CLP formed 6288 social development groups with 133,028 female participants, while 47 sessions were conducted on various social and development aspects. In addition, nearly 100,000 newly married couples attended the marital counselling session.

Livelihoods Training and Support

As most female participants chose cattle as their income-generating asset, CLP provided them with cattle husbandry training to promote maximization of benefits from livestock. To assist this, a network of para vets, known as Livestock Service Provider (LSP), was developed in the chars. For a small fee, they continued to offer advice and services such as vaccinations and deworming tablets even after CLP support ended in a village.

CLP encouraged households to adopt a wider range of livelihood options, such as planting homestead gardens and poultry rearing. To this end, households received inputs such as vegetable seeds, saplings and training. This initiative had the dual purpose of increasing food security among programme-supported families, in addition to diversifying household income sources. During the project period, a total 130,986 persons received livestock rearing training, 124,743 persons received backyard poultry rearing training, 131,560 persons received homestead gardening training, while 644 Livestock Service Providers were trained.

Flood Protection and Employment Generation

While mighty rivers surrounding the chars were a source of livelihood, these also were the source of hardship during the annual floods (June to Sept/Oct), particularly when households were caught ill-prepared. During floods, thousands of char households are forced to leave their inundated homesteads in search of shelter on higher ground. Houses are damaged, assets swept away, and waterborne diseases become a big threat to many families. To help families become more resilient to flooding, CLP raised thousands of households on to engineered, earthen plinths two feet above the highest known flood level (see Chap. 16 on flood proofing in this regard). As additional support, CLP provided infrastructure such as water points, latrines and cattle sheds.

In mitigating the general underemployment situation occurring during these times, CLP provided the extreme poor households with the job of building homestead plinths through a Cash-for-Work scheme. Known as the Infrastructure Employment Project (IEP), the scheme operated during the *monga* period between September and December each year. This intervention served the dual purpose of households having received a much-needed income during the lean season, while the construction of plinths for their homesteads protected families during floods. With CLP's support, 113,978 workers were employed, and 76,117 plinths were raised during the lean season in around 1000 island char villages.

Water, Sanitation and Hygiene (WASH)

Families on the chars sourced their drinking water from shallow tube wells, which generally did not offer quality or safe water. During annual floods, tube wells were often surrounded by floodwater or submerged, which increased the risk of contamination that could lead to various health issues. In improving the quality of water available to char dwellers, CLP added platforms and/ or increased the depth of existing tube wells and installed new ones where needed. All tube wells were placed on plinths so these would be located above flood levels.

In the absence of hygienic latrines and lack of awareness, many of the extreme poor households admitted to practicing open defecation before joining CLP. To tackle this problem and other poor hygienic practices, CLP constructed hygienic latrines and raised awareness of hygienic issues. The programme offered Taka 500–1000 as subsidy to each needy char household in its working areas to fund the construction of hygienic latrines built above flood levels. To promote improvements in WASH practices such as handwashing, female household members and adolescents were trained in sanitation and hygiene skills through local Social Development Groups. With CLP's effort in WASH, 261,300 households accessed sanitary latrines, 225,660 households accessed improved water and sanitation and 145,897 individuals were trained in better hygienic practices.

Health and Nutrition Services

High levels of malnutrition made it difficult for many char inhabitants to fend off diseases like diarrhoea and dysentery. Besides, there was a general dearth of public health services in the charlands. To help with this issue, CLP ran fortnightly satellite health clinics by trained paramedics. These clinics were essentially makeshift camps set up on the chars to offer much-needed primary health care and family planning services to the char communities in CLP working areas. These also included a referral service that directed patients with more serious ailments to mainland government, private, or NGO facilities.

In addition to these health clinics, two types of health workers, all female, were recruited from among the char communities to provide services on a daily basis in the chars: community health workers known as Char *Shasthya Karmi* (CSK), and Char Nutrition Workers known as Char *Pushti Karmi* (CPK). The CSKs were trained by paramedics to provide preventative health care, family planning services and to treat basic ailments. They also assisted at the satellite health clinics. The CPKs were trained to provide nutrition counselling and inputs such as micronutrients, particularly to the pregnant women and lactating mothers and households with children under five years of age. A total of 1357 CSKs were trained while 32,400 Satellite clinics organized, and 1,971,816 patients were served. Besides, total 804 CPKs were trained and 56,832 households received counselling on nutrition.

Formation of Community-Based Organizations

Given the lack of government and NGO services in the charlands, CLP established a range of community-based organizations that encouraged participation and commitment from the wider community to effect deep-rooted social change on the issues related to, for instance, open defecation, practices of dowry/ early marriage and other social issues. A total of 465 Village Development Committees (VDCs) were established to lead the way in addressing such social issues. They also played a role in lobbying local government at both Union Parishad and Upazila Parishad levels as well as NGOs to further engage in community assistance. Village Savings and Loan (VSL) groups were established to fill the critical Access to Finance (A2F) gap and to offer residents of the chars a safe place to save and take occasional small loans. While initially established with CPHHs only, encouraged by the success, non-CLP members were also taken in as separate groups. A total of 8672 VSL groups were formed with around 200,000 women members.

Market/private Sector Development

Due to remoteness of the chars, marketing services available to the communities there have been rather poor. In view of this problem, CLP fostered the development of Char Business Centres (CBCs) and farmer/producer groups for both meat and milk subsectors. It helped to establish 70 CBCs and 261 farmer/producer groups in the operation areas. Business groups provided a valuable forum through which farmers were able to learn from each other. The CBCs, composed of char farmers, input providers and buyers, provided a platform for multiple market actors to regularly discuss ways of improving business environment. CLP also aimed to improve access to inputs on the chars through support to Char Input Dealers (CIDs), who made inputs available to the chars. Besides, it facilitated the growth of livestock enterprises by encouraging microfinance service providers to work on the chars.

Outcomes and Impacts of CLP

Primary Outcomes for Core Participant HHs

The major outcomes and impacts that CLP were in (i) the diversification of livelihoods and connection to markets; (ii) provision of food security and nutrition; (iii) improvement in women's empowerment; (iv) enhancement of water supply, sanitation and hygiene; and (v) resilience in facing environmental and economic shocks. These are briefly discussed below.

Diversification of livelihoods and connection to markets: There were few livelihood options for extreme poor households living on the chars. Prior to CLP, on average, 82.4% of char dwellers income came solely from selling labour. Diversified livelihoods were necessary to cushion these vulnerable families against the supply of and demand for labour. The transfer of an income-generating and livelihoods training allowed women to do exactly this. Over time, families were able to grow their income-generating asset and to buy more livestock, etc. Therefore, by the end of programme intervention, households normally had a healthy range of income sources. Before receiving programme support, a typical CLP family earned 82.4% of its total income from wage labour and practically nothing from land or livestock. By 2015, the proportion of income from wage labour was reduced to 42%; income from land, livestock and other sources covered up the balance (Pritchard et al. 2016).

The next step in CLP's strategy was developing markets. Milk and meat farmers on the chars were traditionally constrained by lack of inputs, knowledge of up-to-date rearing practices and lack of access to markets where they could sell their products. CLP's market activities addressed these issues and tried to bring some systemic change. With CLP's support, 110 CIDs operated on the chars and sold vital inputs such as cattle feed and vaccines. Livestock producer group members met regularly and shared advice and knowledge. With increased access to quality inputs and better rearing practices, livestock business group members started earning higher profits and increasing livestock productivity. CLP also connected char farmers with 190 *paikers* (middlemen, cattle buyers) and 69 *goalas* (local milk purchasers), who travelled directly to the chars to do business.

Provision of food security and nutrition: Food insecurity and malnutrition was a burden on family's health and nutrition status and resulted in loss income due to illness. Besides, learning ability of children can be adversely affected by undernutrition. Issues like these make it difficult for vulnerable families to break out of the poverty cycle. CLP monitored household food security using three pillars: (1) access to food; (2) availability of food; and (3) food utilization. Progress was made in all three areas through CLP intervention. For example, proportion of households 'eating 3 meals per day and consuming at least 5 food groups' went up from 26 to 84% after programme support from CLP (Pritchard et al. 2016: 27). Another indicator that illustrates improvement in food security relates to the percentage of income spent on food. On an average, at the initiation of CLP, over 80% of participant families (as per baseline) spent more than 70% of their income on food while, by 2015, this proportion had fallen to less than 10% of CLP-supported households (Pritchard et al. 2016: 28). The programme also noted improvements in terms of nutrition as mothers' body mass index improved, stunting reduced and haemoglobin levels improved in children.

Improvement in women's empowerment: CLP used a women empowerment scorecard shown in Fig. 20.2 comprising ten criteria which the char communities identified as indicators of women empowerment. A woman was defined as empowered if she met any five of these ten criteria.

Results show that CLP had positive impact on women's empowerment at both household and community levels, resulting from increased knowledge (through social awareness curriculum and training) and increased savings and wealth (through asset transfer intervention and financial inclusion. 86% of Cohort 2, who began receiving support in October 2012, were still empowered in 2015, over one year after the support ended. Before they joined CLP, only 2.3% of these women met five or more of the criteria (Pritchard et al. 2016: 31).

Enhancement of water supply, sanitation and hygiene: There is a proven relationship between poor water–sanitation–hygiene practices and extreme poverty, which is why 30% of CLP's graduation criteria were directly related to these practices. CLP invested in improving existing tube-wells or installing new ones, introducing hygienic latrines, and explaining the importance of good hygiene practices. As many as 225,660 families, including non-CLP households, were provided with access to an improved water source. Overall, 64% of CLP-supported families had access to improved water sources offered under the programme.

CLP helped in reducing the practice of open defecation and increasing the use of low-cost hygienic latrines. After having received CLP support, 82% of the families were found to have access to such latrines, compared to only 13% before joining the programme (Pritchard et al. 2016). Awareness raising and the provision of grants were instrumental in achieving such result. Besides, efforts of Village Development Committees (VDCs) played an important role in this. To monitor success, CLP

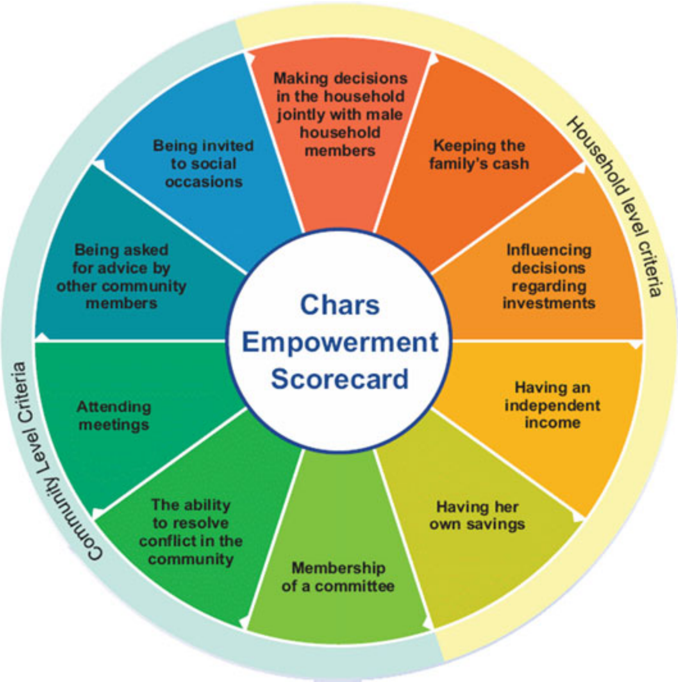

Fig. 20.2 Women's empowerment scorecard

introduced a proxy for handwashing behaviour: making soap or ash available near a water point or latrine. The number of respondents with soap or ash close to their water point or latrine jumped from 15% at baseline to 99% by 2015.

Resilience to face environmental and economic shocks: One objective of CLP support was to enable participating households in becoming more resilient in withstanding environmental, economic and health shocks coming their way. With the transfer of an income-generating asset, training and support, targeted families were able to grow the value of their productive assets and diversify their livelihood. So, they no longer had to rely purely on selling wage labour. Before joining the programme, on an average, households in 2012 had assets of less than Taka 689. By 2015, the value of their productive assets grew to an average of Taka 78,532 (Pritchard et al. 2016).

With more productive assets and a variety of income sources like milk and poultry sales, CLP families were able to accumulate some cash savings. Before joining CLP, households had barely any savings—on average each household had only around Taka 71. After CLP support, mean cash savings increased over time to an average of Taka 3945 by 2015. More productive assets and cash savings acted as a cushion in times of crisis and disaster. Raising homestead, livestock shelter, water points and latrines above flood level enhanced resilience of the households. The plinths also provided sanctuary to many neighbours living in low-lying areas.

Impacts of CLP (Graduation Out of Extreme Poverty)

CLP in its second phase developed a set of criteria to assess if a household was on the right trajectory to graduate away from extreme poverty (see Table 20.1). The criteria considered different dimensions of poverty, from income and assets, to nutrition and women's empowerment. Besides, views of char people on poverty were taken into account in developing the criteria. The target set by CLP-2 in this regard was to graduate 85% of its 78,026 supported households. To have graduated, a household had to meet (any) six of the criteria within three months of the culmination of CLP support. The graduation rate for Cohorts 2.1–2.5 was 88%, which exceeded the target.

Data showed that CLP families, on an average, continued to accumulate their productive assets beyond the 18-month cycle. For example, the mean value of productive assets held by Cohort 2.1 households was Taka 62,413, which, at the time of the survey, was 34 months after the end of support; on the other hand, CLP had some participants labelled as 'Super-Graduates'. Around 48% of CLP graduates belonged to this category, as they managed to accumulate productive assets worth over Taka 74,000, on average (Pritchard et al. 2016: 45).

Learnings from CLP

Key Learnings

CLP learned a lot during the years of its operation (2004–2016). Some of the key learnings, as listed below, would help in further contributing to char development initiatives in Bangladesh.

Sustainability Achieved Through Partnership

Throughout its implementation, CLP maintained a focus on partnerships, with the aim of bringing new resources, relationships and improved goods and services to the chars to help communities continue their journey away from poverty. This approach has met with a number of successes, particularly in areas of market development, health and education. CLP followed Making Markets Work for the Poor (M4P) approach, which emphasized linkages, relationships and partnerships to overcome marketing restrictions suffered by the poor. This, for example, has helped the small-scale entrepreneurs in the meat and milk markets by way of delivering to them larger quantities of livestock feed, vaccines and fodder seeds. In some cases, large agriculture suppliers signed contracts with Chars Business Centres and Chars Input Providers, leading to better supplies and more sustainable businesses.

Table 20.1 CLP's graduation criteria

Criteria domain	Income/expenditure/consumption	Nutrition	Asset base	Status of female	Vulnerability	Access to Services
Criteria	(1) Household has had more than one source of income during the last 30 days (2) Household eats three meals a day and consumes five or more food groups in the past week	(3) HH has access to improved water (4) HH has access to a sanitary latrine with an unbroken water seal (5) Presence of ash/ soap near water point or latrine	(6) Productive assets worth more than BDT 30,000 (£261)	(7) Participant can influence HH decisions regarding sale/ purchase of large investments	(8) Homestead is above known flood level (9) HH has cash savings of more than BDT 3000 (£26)	(10) HH has membership in social group

Source Pritchard et al. (2016)

In the health sector, CLP worked closely with BRAC, handing over 420 'phased out' villages to them for providing sustainable primary health and family planning services. In addition, CLP helped to build partnerships between health providers such as Orbis International[5] and CLP's Implementation Organizations (IMOs) to continue deliver sustainable eye health services to the people living on chars. In the education sector, CLP got the Standard Chartered Bank as a Corporate Social Responsibility stakeholder, thereby providing long-term primary education support in over 20 villages. In addition, partner NGOs of CLP took over 44 of the 150 primary education centres that were piloted under CLP-1 and CLP-2.

Effective Role of the Private Sector

CLP took initiatives in bringing private sector actors on to the chars for people there to connect with the mainstream market system. As a result, char producers got fair prices for their produces. Large agriculture processing companies of the country like PRAN and SQUARE and sourced some of their materials from small and medium farmers in chars. In the case of PRAN, they created their own supply chain network and hubs, also accepting products from groups of farmers/producers/suppliers if they found their specifications were met.

Increased Empowerment of Char Women

CLP targeted the extreme poor households as its Core Participant Households (HHs). One fundamental aim was to improve the status of women and proceed towards gender equality among char communities. CLP's range of interventions included some that were designed to build women's confidence, increase their ability to take control of their own livelihoods and to make decisions impacting their life and the lives of those around them. Interventions were made to also reduce negative social attitude towards women and increase respect for them within the family and the wider community. To achieve this, CLP enrolled women in social development groups where members attended weekly sessions, following a social development curriculum. Sessions consisted of role playing, exercises and discussions aimed at making participants aware of their rights and strengthening their confidence in exercising them.

[5] An International NGO working for the betterment of eye health for poor and vulnerable communities.

Community-Wide Approach Producing Greater Impact

At the beginning of nutrition intervention, CLP targeted its core participants under four categories of clients (pregnant women, mothers of children aged 0–6 months/7–24 months and adolescent girls aged 10–16 years), which raised few questions, like what about other core Participant households (CPHHs) who did not have any member to fit into any one of the stipulated groups? What would be the impact and cost-efficiency limitations of restricting nutrition interventions to just these groups? Subsequently CLP started to include the whole community by introducing the Infant and Young Child Feeding (IYCF) approach to all core and non-core participant HHs, village doctors, newly married couples and adolescent boys and girls in the communities. This approach helped in achieving better results.

Financial Inclusion Helped with Sustained Livelihoods and Business

Despite proliferation of Microfinance Institutions (MFIs) in Bangladesh, these were largely absent in CLP working areas at the beginning of its initial phase. Majority of char households did not have eligibility to join any of the standard MFI groups. So, the only option of loaning money in emergency situations for them was to seek high interest loans from informal money lenders (*mohajons*).[6] To address this problem, CLP offered them a community-managed savings and loan activity, called Village Savings and Loan (VSL) approach with access to loan through collective savings deposit. In 2007 CLP-1 signed a Memorandum of Understanding (MoU) with *Palli Karma Sahayak Foundation* (PKSF), a quasi-government organization that wholesales credit for MFIs, to establish MFI branches and expand microfinance services across CLP working areas. PKSF provided flexible loan support and technical assistance to CLP IMOs and introduced a variety of loan products suitable for char dwellers. With this initiative, around 40 new MFI branches were established which had given access to financial services to around 100,000 households.

During CLP-2, PKSF continued to expand financial services in chars and CLP expanded its VSL intervention simultaneously to non-CPHHs as well. At the end of the CLP, VSL was very large in terms of coverage, enrolling around 200,000 women participants in nearly 9,000 groups. A study on the sustainability of VSL in 2011 found that 32% of the groups were still meeting and saving without support from CLP (McIver and Hussain 2011). It was successfully implemented in 261 farmer/producer business groups and 70 Char Business Centres (CBCs) as an instrument of Access to Finance (A2F) for their business needs and expansion.

[6] *Mohajon* is a Bengali term means local moneylender who usually charge high interest rate, apply rigid conditions for loan and repayment method.

Leadership Role in 1st National Char Convention 2015

CLP played a vital role in organizing the first ever National Char Convention which was successfully held in the capital city Dhaka on June 6, 2015. The main objective of the convention was to raise a collective voice, draw policymakers' attention and mobilize resources to char areas with a view to addressing the sufferings of char dwellers. It sought the attention of government, policymakers, donors and development organizations in addressing the problems of char communities. More than 70 organizations had come on board to campaign for this cause. The Convention brought together the members of the parliament, government officials, policymakers, donors, international, national and local NGOs, researchers, academicians, development activists, representatives from community-based organizations (CBO) and people from numerous chars. Out of around 1200 people participating in this Convention, half were char dwellers. With the slogan '*Let the Light of development spread over the Chars*', this unprecedented national event aimed at determining a consolidated way forward out of poverty for all char dwellers.

Looking Back: Some Final Thoughts

Pathway to reduce or eradicate poverty requires a multidimensional approach, covering the wide range of factors that cause and perpetuate poverty. CLP took this holistic approach in their work with communities living in chars within Bangladesh, addressing livelihood, health, social, environmental and other vulnerabilities that the poor households there face in their daily life. Several studies have been undertaken on lessons learnt from the CLP experience (e.g. Conroy et al. 2010; Maxwell Stamp PLC 2010; DFID 2011). These studies have by and large commended the wide coverage and outcomes of CLP. For instance, Maxwell Stamp (2010: 50), observes, 'Apart from challenging much developmental orthodoxy, the CLP's greatest achievement is the sheer scale of the programme'.

It has been observed that CLP's infrastructure-related work, including plinth raising, would have been more effective had these taken into account the propensity and nature of flood and erosion hazards in the areas concerned. Thus, Paul et al. comment, '…despite plinth raising, erosion and floods negatively impact on participant households' lives. If implemented within the context of chars, future livelihood programming should further investigate how these impacts could be further reduced'. All this would underline the importance of reviewing the practices followed in providing grants for erosion and flood management.

Since households participating in CLP were found interested mainly in the use of their land, it has been suggested that the farmers could be helped more in raising their agricultural productivities. In addition, it would have helped to have better access to markets both for procuring inputs and marketing outputs. A related recommendation has been to look for growth outside of the char communities since opportunities for income generation in the disaster prone chars are rather limited. In this regard, an important consideration would be to ease the access to money transfer services between the chars and the mainland. Finally, to assess the sustainability of benefits accruing from development initiatives like CLP in chars, it would help to include nonparticipating households in the sample selected for monitoring, collecting pertinent qualitative as well as quantitative data. Moves taken by CLP in the health sector have been well recognized. Efforts in this regard should be continued by similar initiatives if positive outcomes are to be upheld. In such work, local government institutions, particularly the Union Parishads need to be effectively integrated.

Notwithstanding the scale of CLP initiative and apart from rooms for improvement indicated above, there are few unanswered questions in the CLP trajectory; like, should CLP have tried to work with more participants, for example by extending its definition of 'extreme poor'; or, what is the appropriate balance between beneficiary-focused livelihoods support and market-focused commercial consideration? While it is admitted that CLP, considered in isolation, has been a costly undertaking, its worthwhileness has been well articulated by Maxwell Stamp PLC (2010: 50), 'The unit costs of the CLP approach are high but much lower than a lifetime on food aid'. It may be concluded that the experience gained from the multidimensional initiatives of CLP should prove helpful to individuals and institutions towards developing and implementing programmes in providing char communities of Bangladesh with a better life.

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Chapter 21
Sandbar Agricultural Technology and Innovations in Chars

A. Z. M. Nazmul Islam Chowdhury

Abstract This chapter describes climate-adaptive and innovative agricultural technique called "sandbar cropping" that helps the poor farmers displaced by recurrent river erosion in producing food crops like pumpkin on transitional riverbeds or chars. The sandbar cropping project was initiated by Practical Action to organize and assist erosion displaced families without land to access the newly deposited charlands during the winter season. This experimental project has demonstrated that production of pumpkins and other high-value crops in small compost pits dug into the sand is both possible and profitable. The project has mobilized a total of 22,131 farmers (more than 65% of them women) over the last 15 years and has produced 158,000 MT of pumpkins worth 37.8 m USD by adopting the innovation and low-cost reservior irrigation techniques in chars. This innovative agricultural technique has great prospects for char regions in the country.

Keywords Transitional charland · Sandbar cropping technology · Pumpkin production · Poverty reduction

Introduction and Objectives

Flood and erosion disasters are common in Bangladesh. Erosion displacement in the floodplains renders a large population landless and homeless every year, destroys assets, depletes savings and affects employment and incomes. The land-man ratio is already poor in Bangladesh. Yearly flooding and erosion of banklines and chars keep accentuating the problem, resulting in higher risks of food security and increased level of poverty. The new land that re-emerges every year in the form of low-lying sandbars or chars are used as agricultural resources by the displaced poor families in the floodplains. These sandbars or transitional charlands[1] are used only during the

[1] The terms sandbars/chars are used in this chapter to refer to "transitional" lands that appear and disappear with every flood season.

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winter/dry season (October to May) as they are subject to continual change, erosion and reformation during subsequent flood seasons.

The primary purpose of this chapter is to introduce and discuss the new sandbar agricultural technology and innovations in agricultural production in charlands that are often “transitional” in nature. Increased use of sandbar technology in the chars offers poor landless and farming families some hope of growing crops for livelihood and income. The focus here is on sandbar agriculture and pumpkin cultivation and marketing. The sandbar technology was developed through a series of action research over a period of five years (2005–2010) in Gaibandha district in the northwestern region of the country by Practical Action-Bangladesh[2] under the *Disappearing Lands Project*. This farm-based trial provided the resource poor displaced communities with a much-needed opportunity of food production in new charlands, thereby helping them with their nutritional needs and income generation, particularly during the lean period, which is locally called the *monga* season in the northwestern part of Bangladesh. In a country desperately wanting in arable land, the sandbar technology promises to be an important coping strategy in the silted sandy chars that are commonly impacted by riverbank erosion and threatened by climate change.

The Context and Settings

In Bangladesh, the three major rivers—the Ganges, Brahmaputra and Meghna—traverse the country. Between them, the rivers force huge quantities of water and silt into the waterways, over-taxing the carrying capacity of their distributaries. The three rivers also force some two billion tons of sediment into the waterways of the country, causing widespread silting of river beds, bank overflows, strong currents and erratic channel shifts as choked waterways are forging new outlets (see Chap. 8). This means that the main rivers of the country are highly unstable, turbulent, and given to frequent changes in course bringing immense misery to a significant portion of the population, especially to those living along the banklines and chars. As a result, floods and erosion are constant threats to emerging charlands and sandbars throughout the floodplains and the lower Meghna estuary.

The northwestern region of the country is nationally recognized as an economically disadvantaged and highly food insecure area. Five districts of Rangpur Division, including Gaibandha, lie close to the confluence of the two major rivers of the country, Teesta and Brahmaputra (Hossain 2012). This area is ravaged by flood and erosion almost every year, with large areas of land lost to the river, disrupting lives and livelihoods of the inhabitants. However, after each flood season, large sandy islands or chars appear within the rivers, which are often transitional, temporary (not all, some are more permanent and stable) and barren lands made of coarse sand, with limited

[2] The Practical Action-Bangladesh, an NGO funded by a British charity, designed and executed the sandbar innovation technology as well organized the char people and other stakeholders. The author played a key role as the Lead-Agriculture in establishing the program in Gaibandha District.

or no silt at all. These sandbars or mini-chars emerge either as transitional islands in the river channel or (less often) as attached land to the riverbank.

With a high population density of over 1000 people per sq. km in the country, the new charlands offer an opportunity of livelihood to local farmers to produce crops as best as they can in the new land, even if the land is only temporarily available. Innovative technologies like sandbar agriculture, by way of year round production, can help in meeting the need for food for the ever-growing population in Bangladesh. This is more so when a huge mass of land—an estimated 2709 km^2 of newly accreted charlands—is annually available between October and April in the Teesta and Brahmaputra river system (IWM and Practical Action, 2018; Chowdhury and Bepary 2006). The charlands of the three main rivers the Jamuna-Brahmaputra, Ganges-Padma and Meghna cover some 8450 km^2 (6% of the total land area) with a population of 6 million in 1992–93 (see FAP 16/19, 1993), which now has increased to 12 million (Thompson and Tod 1998; EGIS 2000; Islam et al. 2010).

Sandbar Cropping and Its History

Sandbar cropping is an innovative, cost-effective and climate-smart technological solution that transforms silted barren sandy lands created by flooding into arable farmland (Chowdhury and Bepary 2014; Chowdhury 2016). This cropping technique was developed through a series of initiatives in the Rangpur Division under the "Disappearing Lands Project" under Practical Action Bangladesh. The initial trial began with 177 farmers in 2005 (see Fig. 21.1). The second phase of the project was funded by Economic Empowerment of the Poor (EEP) as a joint initiative between

Fig. 21.1 Aerial view of sandbar cropping in 2020. Pumpkin Plus, Bangladesh 2019

the Governments of Bangladesh and the UK. This was designed to benefit 85,000 households whose villages and farms had been lost through river erosion in five districts in the northwestern part of Bangladesh covering 9000 km^2, who had been forced to live on flood protection embankments after losing their home and livelihoods. In 2005, Practical Action encouraged community members in chars to sow pumpkin seeds and a wide range of other high-value crops, including flowers and fodder.

Sandbar cropping is a method where farmers dig holes in sandy land and fill these with manure, compost, and pumpkin seeds. At the early stage, Practical Action provided the farmers with agricultural inputs and necessary technical help. Sandbar technology does not require large-scale irrigation as the land is close to the river channel. As the river channels make a rapid retreat in the dry months, groundwater is eventually used through boreholes made with the help of diesel-operated pumps.

Underground water from the riverbed is generally tapped at a depth of 15–40 feet. Water is often pumped from the hole through polythene pipes into a makeshift small-sized water reservoir covered by low-cost polythene sheets (Fig. 21.2). These reservoirs lie in the proximity of the pits, and water is manually transferred to the pits using buckets. In the sandbars, farmers often dig temporary reservoir to collect rainwater and source water from the floodplain itself.

The degree and frequency of irrigation depend upon the quality of the sandy soil and the amount of rainfall during the period of plant growth. The technology is useful for producing vegetables like pumpkin, squash and watermelon. It can also be used for the production of flowers and grasses as cattle feed. Area devoted to winter pumpkin cultivation as well as its productivity have increased over the years.

Stakeholders Mobilization and Participation

Practical Action adopted a step-by-step approach in selecting stakeholders and identifying farmers—both men and women—based on interest, capacity, skills and enthusiasm to go along with such a new technology. Initially, it was a challenge to convince

Fig. 21.2 Farmers dig holes using local technology for ground water (left) and harvest rainwater (right) for pumpkin and other high-value winter crops. *Sources* Mizanur Rahaman 2018 (left) and Salman 2020 (right)

people in believing that the sandy land could produce something. This required five months of continuous engagement; with pitting, seed sowing, small irrigation and inter-group management.

Steps followed in the process of mobilization and participation included: (i) identification of sandbars by individual communities immediately after recession of floodwater; (ii) spot survey and data collection; (iii) selection of sandbars and listing of interested farmers, including any claimants of the new land[3]; (iv) meeting with local administration for informal permission to use the land for sandbar cultivation; (v) local workshops with all stakeholders regarding use of the land; (vi) securing agreement from all stakeholders, including local administration and line departments for necessary support and services; and finally (vii) technical orientation and ground level actions for cultivation. Provided the land reappears at the same location, concerned farmers gain access to it in the following year, and the cycle repeats itself. In the project area, these steps are now practiced almost as rituals every year.

Cultivation of Pumpkin in Sandbars

The technique of pumpkin cultivation in sandbars is labor intensive. Pit preparation starts around October–November, following recession of floodwaters from. Between 12 and 15 kg of cow dung and 50 g of TSP are put in each pit (see Fig. 21.3). Seeds or seedlings are placed after seven days. During the interim period, the soil and manure are pulverized well and decomposed in the soil. Later, the top dressing of fertilizer is used at different stages of plant growth.

All types of winter vegetables—pumpkin, squash, watermelon, turnip, lettuce, tomato, sugar beet, sunflower, etc. can be grown successfully in this process. Watering the pits is done in accordance with moisture condition of the pit soil. Typically, four to five liters of water would be applied twice a week; which is increased to eight to ten liters three times a week during the flowering and fruiting stages. Weeds are

Fig. 21.3 Pit preparation for pumpkin cultivation (women providing most of the labor). *Source* Mizanur Rahaman (2018)

[3] Newly emerged charlands legally belong to the government and considered *khas* land until these are surveyed and ownership identified by the Land Records and Survey Department (see Chap. 24).

not common in sand beds. When grown, these are either uprooted or left there to be decomposed. Soil near the roots is pulverized in case crust develops there. Fertilizers are applied in various stages in the pits, watering after each application.

Pumpkin is the most profitable of all crops grown in sandbars. Pollination is usually facilitated by bees and other insects. However, when this is not adequate, artificial pollination is resorted to. With artificial pollination, pumpkin production in certain cases reportedly rose by 25–30%. Red pumpkin beetle is a common insect pest, attack from which is controlled by using traps in pumpkin fields (Fig. 21.4). Disinfected seeds are often used for controlling disease in the subsequently growing crops.

Pumpkins may be harvested at any stage of maturity. It can be preserved at normal temperature, if harvested after maturity that is when fully ripened (Fig. 21.5). It supplies food and nutrition for the family when vegetables are scarce during the rainy season, particularly in the event of floods. Pumpkins are sold in the market throughout the year. Several recent studies have highlighted pumpkin production and its impact on the livelihood of char people, who are in a constant struggle for

Fig. 21.4 Pest control kit in pumpkin field. *Source* Nazmul Chowdhury (2020)

Fig. 21.5 Pumpkins ready for harvest (proud female farmer holding couple of pumpkins in her hands). *Sources* Mamun (Kurigram 2018); Nazmul Chowdhury (Gaibandha 2008) and Mehrab Gani (Rangpur 2012)

Fig. 21.6 In-house storing of pumpkin and transportation to local/long distant markets by *pikers*. *Sources* Iqbal Hossain (Gaibandha 2008) and Mizanur Rahaman (Rangpur 2020)

their food and survival. Nahar et al. (2016) studied sweet gourd production under sandbar cropping practice and found it highly profitable, having a significant positive impact on the livelihood of households, particularly for women in the char areas. The benefit–cost ratio (BCR) was 2.43 (Khatun et al. 2017) and may vary based on the investment patterns of farmers. Prior to sandbar cultivation, women had no access to economic activity or resources (Practical Action 2016). The SWFF featured on USAID's Global Water Blog that pumpkin cultivation in sandbars is one of the water-saving techniques contributing to global food security (SWFF 2019).

Sandbar cropping has so far helped tens of thousands of farmers in transforming acres and acres of mini-deserts into plentiful fields of crops (Minh 2017). Pumpkin is a high-yielding crop, and an estimated 30 to 40 tons of it may be harvested per hectare. Farmers can store pumpkins for sometimes in their houses without any additional efforts. However, most farmers sell their pumpkins to collectors (*piker*) or local consumers, preferring to sell ripe pumpkins for cash. They also have access to nearby local markets once or twice a week and can sell both green and ripe pumpkins in bulk there (Fig. 21.6). Normally, very limited retailing takes place in these markets. Farmers do not usually travel to large urban markets for selling their output since these are usually far from the char villages, traveling to which entails additional labor and transport cost. The *pikers/* wholesalers in turn sell the products to kitchen markets/supermarkets or processing plants in large urban centers, district towns or national markets. Pumpkins being quite heavy, farmers are usually reluctant to carry these to distant market places all by themselves.

Empowerment of Women/Stakeholders in Chars

Sandbar technology and pumpkin cultivation introduced by Practical Action Bangladesh over a decade ago have contributed to reducing poverty in certain areas in the northwestern part of Bangladesh. Pumpkin cultivation and income therefrom seem to have made the participating households more self-reliant and cut down the frequency of their migration to urban areas for temporary employment. It was found that after three to four cycles of sandbar cropping, farmers were able to stabilize their income from about Taka 100 to Taka 250 per capita per day. Over 65% of the total participating beneficiaries were women. It shows that women are capable of being involved in agriculture. Thus, apart from providing food and raising income for the participating households, sandbar cropping can help reduce gender inequality to an extent.

Sustainability, Resilience and Livelihoods

There, however, are challenges in the practice of farming in sandbars, for instance, ownership rights, climatic conditions, production and marketing constraints (see Chaps. 17 and 24). Sustainability of sandbar technology is evident in that a large percentage of trained beneficiaries, following withdrawal of external support, have continued practicing the technology with their personal investment, in some cases multiplying their income many folds. To date, the innovation has reached 22,131 farmers with direct project support, of which over 65% are female. Additionally, secondary adoption (by way of following the example) recorded around 9000 farmers in the region (Jahan et al. 2017).

In 2019, after the withdrawal of external support, the author established Pumpkin Plus and organized the same producer groups to transform sandbar agriculture to a more profitable agribusiness system by the poor, moving away from a donor based approach to a producer-driven commercial model, involving women and youth in the char areas, and through a village-based market system led by the community, including women farmers, for food security, employment and income.

Issues and Challenges

Sandbars are physically dynamic entities, characterized by water flow and flood situation over time. Ownership of land in sandbars is a crucial issue in ne crucial issue. Since the sandbars are not stabilized, they belong legally to the government until proper survey, mapping and ownerships are determined by the Directorate of Survey and Records (see Chap. 24). The land reform act of 1997 had provisions for access to such lands by the poor through re-distribution but the local District administration, a measure which is consistent with the history of laws and ordinances in the region going back to the East Bengal Acquisition Act as well as the tenancy Act of 1950. However, in reality, once the sandbars become permanent and stable, they become sources of local conflict and dispute over ownerships (see Zaman 1991) and locally powerful and wealthy peasants benefit from delays and loopholes in the survey and mapping of the new char lands (see Chap. 24). Future charland laws should ensure access and ownership of charland to the poor, which will make a big difference to their wellbeing.

Summary and Replicability of the Sandbar Technology

Sandbar technology in agriculture and the cultivation of pumpkin introduced by Practical Action Bangladesh has led to increased resilience and livelihoods for the poor in the chars. Due to its immense potentials, the sandbar technology innovation has now been incorporated into the Bangladesh National Agriculture Policy-2018. It is estimated that by 2050, the country's population will grow up to 200 million, with nearly 35% of the currently arable lands likely be lost to erosions (Ministry of Environment and Forests 2015). This shows the importance of using transitional charlands to the optimum for guarding against food insecurity in the coming decades.

There is also a huge potential for this sandbar technology in the riparian areas in many of the South Asian countries, particularly India, Nepal and Bhutan. In 2018, the South Asian Association for Regional Cooperation (SAARC)'s Agricultural Secretariat took an initiative to replicate Sandbar cropping in at least three countries—i.e., Nepal, Bhutan and India—as a cross-boundary trial to benefit the landless poor. With the new initiative in mind, SAARC Agriculture Center (SAC) is collaborating with various organizations and agencies in the region, including a number of NGOs, toward defining an overall strategy. A high-level technical team visited the sandbar cropping fields in Gaibandha, followed by a consultation workshop (26–31 March, 2018) at the Rural Development Academy, Bogra.[4] Given the realities of South Asia's vulnerability to climate change, SAC's approach to adopt the sandbar technology in the region will accelerate agricultural production and thereby support extreme poor and marginal farmers to reduce their vulnerability and ensure food security.

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Chapter 22
Char Development and Settlement Project: Experiences and Reflections

Koen de Wilde

Abstract This chapter presents the activities of the Char Development and Settlement Project (CDSP) in the southern part of the Greater Noakhali Area in Bangladesh and the context in which they took place. The project design was based on the conviction that the many vulnerabilities that char settlers have to face could not be addressed by a single intervention. A multi-sectoral and multi-institutional approach was thus required. Various aspects of char development are given attention, guided by the key elements of CDSP: land settlement (provision of land titles), forestry development, protection of land by creating polders, construction of internal infrastructure (such as cyclone shelters, roads, ponds, tube wells), and agriculture development. Institutions play a vital role in the project by safeguarding the integrated approach and the participation of all involved parties, from national departments to community-based groups. In case of CDSP, these combined interventions, planned and implemented by a multitude of government departments and NGOs, have led to a socio-economic transformation in a number of coastal chars with substantially improved livelihoods of the settlers. The chapter concludes with reflections on future char development, based on CDSP's experience.

Keywords Coastal Bangladesh · Erosion and accretion of land · Land settlements · Polders · Infrastructure development · Livelihoods and CDSP experience

Introduction

Background

Coastal livelihoods in Bangladesh are endangered. Major threats to people living in the coastal zone are cyclones and storm surges, drainage congestion and water logging, droughts and salinity intrusion, erosion, and deteriorating ecosystems. Most of the households, in particular in the exposed coastal areas, have been subjected to

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poor socio-economic conditions. Against this backdrop a comprehensive development program was initiated, the Char Development and Settlement Project (CDSP), focused on the chars in the Lower Meghna estuary.

The "core business" of CDSP is providing security in physical, economic, and social sense by improving water management conditions, building basic infrastructure, creating better conditions for productive development (agriculture, fisheries, livestock) and the provision of land titles for landless households. This chapter summarizes the activities and the setting in which they were implemented. In doing so, a more or less sequential order is followed. The first phase of the project started in 1994. Three subsequent phases followed, each time shifting to a different part of the central region of the coastal zone (see Map Fig. 22.1).

Emergence of Chars

The Meghna estuary is the most dynamic part of the Bangladesh coast. The erosion and accretion of land are the outcome of very complex processes, with a number of factors playing their roles. Dominant factors are the sediment load coming down from the Ganges–Brahmaputra and Meghna river systems, as well as the transport and distribution of the sediment. Upland flows, tidal forces, and circulation in the estuary play an important role as well. Apart from sedimentation, erosion can be observed. It is caused by the strong seaward flows from the three rivers. Long-term factors as shifting of river mouths contribute to the pattern of erosion and accretion. Surveys from satellite images of the central, dynamic part of the coastal zone for the period 1973–2000 show an average annual net accretion of around 19 km^2, the balance of 32 km^2 of erosion, and 51 km^2 of formation of new land. More recent experience (2001–2008) points to an increase of net annual accretion of around 25 km^2 (Carvajal et al. 2011). The annual rate of increase in the level of the accreted land varies, mainly dependent on the local circumstances of water flows and presence of sediments. The Forestry Department is in control of the accreted land for a period of 20 years, before it is transferred to the Ministry of Land. However, more often than not the new land is illegally occupied by settlers, as soon as people think that some sort of livelihood is feasible there. Once the 20-year period is over, the government decides on allocation of the land to institutions and individuals.

Migration into Newly Formed Charlands

When newly formed chars become fit for cultivation, households will move into the new land, even when it is affected by low-level flooding every day and when it is still under control of the Forest Department. The department simply lacks the staff and other means to stop this illegal occupation. In most cases a locally present *jotedar* (landowners), usually with ancestral links to the area, extends support and

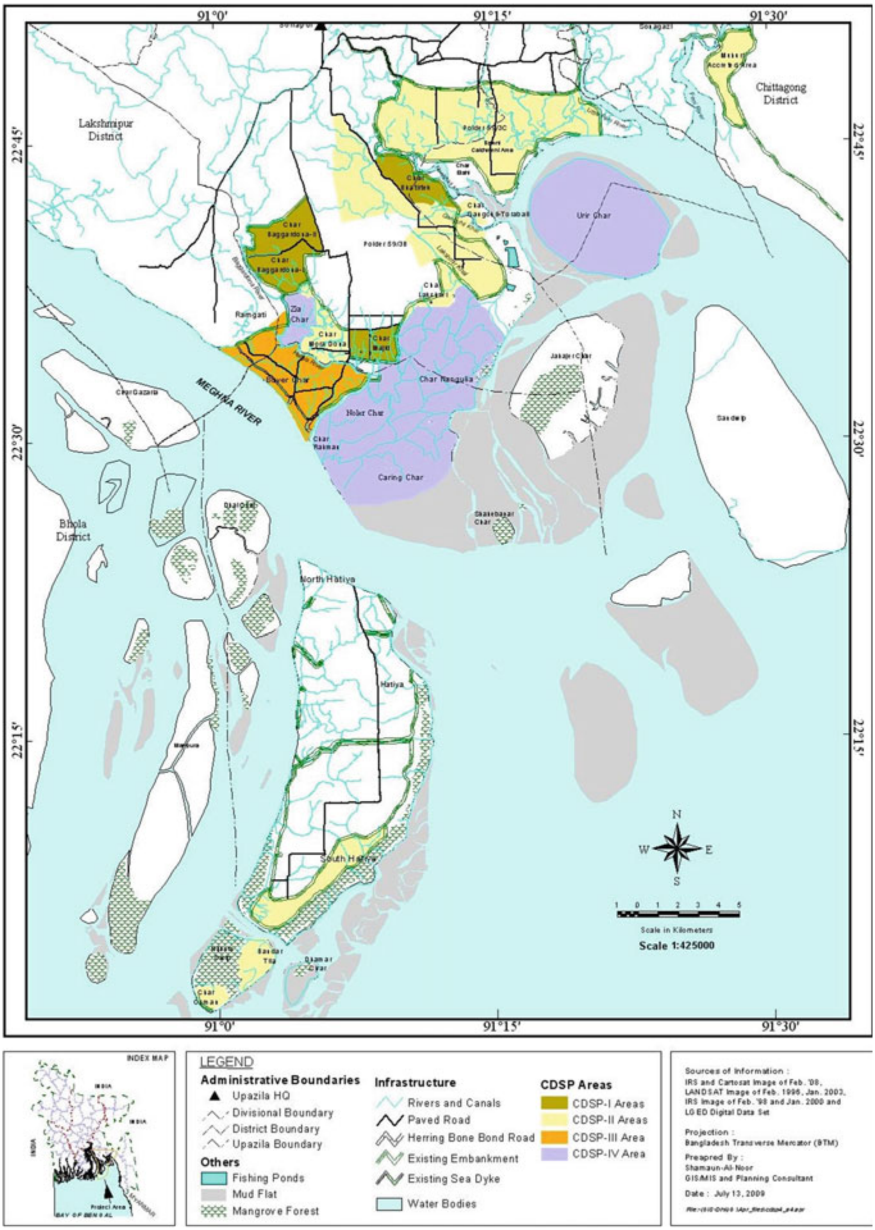

Fig. 22.1 Project area and location of CDSP I–IV. *Source* CDSP (2018a, b, c)

patronage, in exchange for a part of the crop yield or for cash. The migration occurs for a number of reasons. In large part (probably 80–90%), the in-migrating households lost their land somewhere else because of erosion. Other households were victims of coercion and threats in their own area or were attracted by the prospect of government-led development plans in the new chars. There are also families that just accompanied their neighbors. In general, extreme poverty was the underlying motivation to migrate. Most of the families that settled in the coastal chars in the estuary came from relatively nearby places, with 40–45 km as the longest distance to their ancestral homes. Migration takes place over an extended period, increasing over time, till the land is no longer attractive because of overcrowding and diminishing economic prospects.

There is ample and well-documented literature about the relation between natural phenomena and migration (see Islam 2017), including studies on char lands, both riverine and coastal chars. There are common observations, much along the lines of the experiences in CDSP sketched above: relatively short distances between original place and place of settlement, a mix of motives to migrate (natural threats, social and economic considerations) and the presence of powerful, coercive middlemen representing the interests of influential parties from the mainland (see for instance Zaman 1988; Sharmin 2013).

Though many settlers want to stay close to families that they already know from their original areas, the overall composition is rather heterogeneous. Communication between households and participation in larger social networks will gradually become more intensive. In the initial phase, the tea stalls provide the first stepping stone. The more or less formal clustering of people in many instances then leads to the formation of a *samaj*, a small number of households that live in close association and perceive themselves of having a separate identity in the larger community of settlers. Reasons of forming a samaj are safety, protection, and pursuing shared interests. They are autonomous groups, not attached to a higher religious or secular authority, with conflict resolution as an important function. The samaj brings together people who share common religious beliefs and practices and is an important social organization of mutual reliance (see Zaman 1991; Wiest 1991). Beyond the samaj, religious institutions such as mosques and *madrassas* play an important role in the early years of community development in the new land, possibly contributing to the conservative character of the char society at large. Samaj and the religious institutions provide essential avenues for the settlers to become part of a wider social network and of obtaining and maintaining some sort of identity. These avenues may be described as “home-grown,” created by the settlers themselves.

The Project and the Approach

The previous sections picture the situation that CDSP usually encounters when it becomes operational in new areas: still low-lying unprotected chars, subject to frequent flooding, but already occupied by migrated settlers. The design of the project was based on the conviction that the overwhelming vulnerabilities that these people have to face, cannot be effectively addressed by one single activity. It, therefore, calls for a multi-sectoral and hence for a multi-institutional approach, with a central role for governmental departments, given the kind and magnitude of required interventions. The basic idea in the relation between the involved institutions was that there should be a process of common planning, followed by individual implementation: every institution does what it does best, with separate money flows for each of them. Realization of such a setup hinges on a proper accommodation in the formal planning procedures of the Bangladesh Government. This led to an umbrella Project Concept Paper for the project as a whole and individual Project Proforma's for each of the sectors.

Policywise, three concepts stood central from the start: poverty alleviation (improved living conditions for char settlers, in particular more security), participation (involvement of settlers during planning and implementation), and integration (common planning, coordination during implementation, government-NGO cooperation). All activities initially started around the use of the new land resources. Expansion to other relevant development sectors such as health and education has been avoided in order to keep the span of activities manageable. However, participating NGOs are working to a limited extent in social sector activities.

Key Elements of CDSP

Land Settlement

The reference to "settlement" in CDSP's title points to the aim of the project to provide land titles to landless families that are living on the new chars. The fact that they already moved there before the project became operational in a particular area, did make the whole process even more complicated than it intrinsically already was. In 1972, a law was enacted stipulating that all newly accreted land had to be treated as government land (*khas* land). However, an Act of 1994 brought the following limitation: on land formed on the same site where land existed before, the previous owner maintains all rights for a period of 30 years, with a ceiling of 60 *bighas* (almost 20 acre) of agricultural land per household. The provision of land titles belongs to the authority of the Ministry of Land. Settlement of *khas* land is conducted on the basis of the Agricultural Khas Land Management and Settlement Policy of 1997. This means that *khas* land will be distributed among households with no homestead and no cultivable land, and households with a homestead of maximum 10 decimals (0.1 acre). The upper limit of the land that each family can receive, is set at 1.5 acres.

Given the legal and policy context, CDSP met a number of complexities often related to ancestral claims, to claims from government departments and to border disputes in the accreted areas between administrative entities (Districts, Upazilas, and even Unions). Another problem was that shrimp cultivators were active in trying to have the government allocate khas land for shrimp culture. These issues further complicated the already cumbersome and lengthy procedure of land settlement. It should also be noted that upon entering specific char areas, CDSP encountered a socio-political context with linkages between local *jotedars* and powerful entities from the mainland, the use of violence and the influence of vested interests, both public and private as vividly described in Zaman (1991) and Feldman (Feldman and Geisler 2011).

The procedure, from identification of available khas land to provision of a land title (*khatian*) to individual households, consists of 16 steps (for more, Chap. 24). Many of the activities take place at district headquarters (Office of the Deputy Commissioner), far away from where the settlers live. In CDSP, the Ministry of Land, as one of the partner institutions, introduced an adjusted procedure, reduced to eight steps, shorter in time, more transparent and efficient, and closer to the people themselves. This streamlined process boosted the feelings of safety and confidence among the landless families. Their confidence suffered in many cases because of the questionable quality of the land records management system. This system is still manually updated at Union-, Upazila-, and District level. CDSP developed software to modernize the system and applied the computerization for the land settled within the framework of the project. It could benefit the whole of the country if the government decides to apply the shortened settlement procedure all over Bangladesh and to further test the computerization of the land records by extensive pilots in other areas. The government should also address the border disputes in newly accreted land by introducing a standardized, transparent mechanism of conflict resolution.

To date, a total of 33,000 of hitherto landless households received a khatian in the four phases of CDSP (CDSP III 2010; CDSP IV 2018b). In the initial years, the project followed a cohort of about 500 families that received land, to get an answer on the intriguing question whether they were able to hang on to the landholdings. After a period of ten years, 80% of the households were still present in the area; among them households that sold part of their land, others purchased additional land. Twenty percent sold their land and moved out of the area, in a number of cases to chars that emerged later than the land they received (Chowdhury and Latif 2011). The inevitable conclusion is that, on the one hand a vast majority of families were still settled in the area and were using the initially allocated land. On the other hand many illegal land transfers had been going on. Illegal, because the khas land policy of 1997 states that land received under that policy cannot be sold.

Forestry Development

The benefits of afforestation of coastal chars are threefold: greater safety, enhanced ecological circumstances, and improved economic conditions. Experiences have shown that loss of lives and devastation of infrastructure have been significantly less in areas that were surrounded by a forest belt. Trees dampen the impact of wave action and winds. Mangroves protect soils against erosion and add organic material to the soil. They accelerate the formation of new land, while coastal forests form a natural spawning ground for many species of fish. And in general, forests enhance carbon sequestration. Growing trees create economic opportunities through the production of fruits, fuel wood and timber, and of raw materials for a wide range of industries from leather tanning to board mills and match factories.

As mentioned earlier, during the first 20 years, the land is under the authority of the Forest Department, challenged however in many cases by illegal occupation, with destruction of the mainly mangrove plantations as a consequence (see Iftekhar and Islam 2004). In a study in Noakhali coastal forest areas, respondents identified as the three main causes for mangrove destructions: stripping by petty criminals in collaboration with local political leaders, lack of proper action by law enforcing agencies and indeed encroachment by landless migrant households (Sajjaduzzaman et al. 2005). The destruction created a tense relation between the Forest Department and the settlers, which spills over to the initial phase of CDSP's presence. Applying the social forestry approach, spelled out in the National Forestry Policy of 1994, and underpinned by the establishment of a Social Forestry Wing in 1999, CDSP mitigated this unfortunate situation. Gradually a partnership developed between the population and the Forestry staff. Social Forestry Groups (average size 24 members, 60% male and 40% female) were formed on the basis of benefit sharing agreements, with roughly half of the profits distributed among the members. Their most important planting and maintenance activities were along the road, canal, and embankment sides and public institutions.

Infrastructure Development and Public Amenities

There is immense significance of infrastructure for the livelihoods of households living in coastal areas. The (re)construction of coastal infrastructure deserves the highest priority. Embankments protect against inundation while roads and cyclone shelters are vital for rescue and rehabilitation in case of storm surges. The equality of distribution of such facilities is a major consideration. During the process of land formation, there will be a moment that a decision has to be taken whether to leave the new land unprotected or to protect the area and its vulnerable inhabitants by constructing a polder. The most important factor in taking such a decision is the land level. Experience has proven that there is no absolute level of land (for instance 3 m. above PWD, benchmark of Public Works Department). The practice in most locations: land levels will have reached around 3 m above PWD before the construction of a polder is contemplated.

In areas high enough to be embanked, CDSP created polders (nine in all four phases, ranging from 1500 to about 10,000 ha.). This entails the construction of sea-facing and internal embankments, drainage canals, and water regulators (sluices). Essential design considerations for embankments are their location, height of the crest level, and stability. In the dynamic environment of coastal chars, it is important to position an embankment with some distance from the shoreline, with a view to possible future erosion. For the overall drainage capacity of a polder, BWDB practices as benchmark a 10 days rainfall period with a return period of 10 years. The drainage system should be based on the already present network of canals, reflecting the natural topography and land slopes. The most suitable location of drainage sluices should obviously be taken into account.

Given the harsh physical conditions of newly formed coastal chars, it is not surprising that development of infrastructure is a top priority for the families that moved there. In consultation with them, an infrastructural program was designed, essentially evolving around safety, basic needs and productive capability. In chars that were left unprotected in order to make further sedimentation possible, deep tube wells for drinking water were installed and additional ponds were excavated, surrounded by low dykes. Following government policy, a deep tube well was installed for every 15 households. In order to avoid arsenic pollution and saline water, the tube wells had to go as deep as 1000 ft. Roads (that can be used as escape routes to safety behind existing embankments) and cyclone shelters were built, and sanitary latrines were provided. Chars that were protected had roughly the same package of internal infrastructure, plus of course the structures related to a polder. The rural roads were mud roads, only a few were carpeted. Each household received a sanitary latrine. Community ponds were dug, to be used as sweet water reservoir and facility for aquaculture.

In the subsequent phases of CDSP, various cyclone shelter designs were used, in the latter phases taking into account the use of the shelter as a school and always with space that could accommodate about 2500 persons. Under phase four, data were gathered on the availability and utilization of cyclone shelters. The average distance to the cyclone shelter was 0–7 km. During two cyclones, 56% made use of a cyclone shelter, 40% stayed home, 3% fled to higher land, and 1% went to the market (see CDSP IV 2017).

Agriculture and Crop Production

Especially in practically virgin areas, ecosystems determine in large part the possibilities for crop agriculture. Key elements are the availability of water and the characteristics of the soil. Fresh water is scarce in coastal areas. Sources are direct rainfall and water stored in water bodies as ponds on homesteads, community ponds, *khals,* and rivers. Water quality in the estuary itself changes over the year, with high salinity in winter and hardly any in monsoon time. Rainfall varies per season as well, with 50–70 cm a month in the summer to virtually zero in winter. The total annual rainfall in the area amounts to about 300 cm. It is government policy to restrict the use of groundwater to human consumption. Soil salinity is a major impediment to crop cultivation. The annual cycle shows a maximum soil salinity in March and April, while in monsoon time rain causes a sharp decline in salinity of the topsoil. The young soils of chars gradually gain in productivity by the addition of organic matter.

Many of the project interventions aimed at improving livelihoods of households by increasing crop production. In unprotected areas, farmers were supported in selecting the best crop varieties for their specific situation. Typically, they would have one rice crop of a traditional variety in monsoon time. Modern varieties were not feasible, due to problems in controlling water level. In the *aus* season (between summer and winter), only a limited area is suitable for growing paddy. In winter, cultivation of vegetables (such as chili, sweet potatoes, grass peas, linseed) is practiced in those areas where the soil salinity is tolerable. Extension efforts were focused on introduction of such higher yielding crops as water melon, okra, soybean, and groundnuts. Seasonal community ponds were made deeper, increasing their capacity to hold fresh water.

In polders, the beneficial effects on agriculture were much more profound than in unprotected chars. Through a system of embankments, regulators and drainage channels, water levels on farms could be controlled and floods prevented; this had a knock-on effect on soil salinity with a downward trend over the years. This again led to a new environment where more land became cultivable during more cropping seasons (higher crop intensity) and where the adaptation of high yielding crop varieties was possible. These two factors, combined with the introduction of techniques for field- and soil management suitable for the coastal zone, led to a much more favorable overall crop production.

In new polders, the cropping intensity rose from around 115% to over 200% within a period of ten years, with a sharp increase in land under cultivation in the *rabi* and especially aus season. Yields in already grown winter crops rose spectacularly (for instance, for groundnuts from 1100 to 2500 kg/ha, chilis from 4400 to 6800 kg/ha), while new crops were introduced (water melon, tomatoes, cucumbers, and others). There are indications that *boro* HYV rice production (in the winter season, mostly using sweet surface water for irrigation) is becoming more popular. Aus paddy production was expanded, with HYV yields of 3600 kg/ha. Shift to HYV in the *aman* season led to an increase in yields from 2100 kg/ha (local variety) to 4000 kg/ha. Adoption rates of HYV rice were, however, quite erratic over the years. Farmers hesitated to change because of a few disadvantages associated with HYV rice cultivation, often due to higher risk of damage to seedlings, the lower tolerance of soil and water salinity (Sattar 2011).

The transformation of chars into protected land leads to some interesting changes in fisheries and livestock. Conditions for aquaculture are much more favorable. Extensive grazing grounds for large cattle herds are disappearing, shifting emphasis to poultry rearing and making a degree of intensification of animal husbandry of ruminants necessary. A separate chapter in the book discusses the impact of fisheries and livestock on people's livelihoods (see Chap. 23).

Institutions and Community-Based Groups

In essence, the aspects of integration (primarily shared planning and individual but coordinated implementation, both with participation of the households involved) were safeguarded by the institutional setup of CDSP. In the system, government departments had a dominant role, with coordination mechanisms at several levels. NGOs delivered services, complementary to the ones provided by the government. Local government institutions and community-based groups were involved early in planning and participated in implementation as well.

The government departments that were involved in CDSP gradually grew in number. During CDSP I (1994–2000), there were three: BWDB (for construction and periodic maintenance of all water management-related infrastructure), LGED (the same functions for roads, bridges, culverts, cyclone shelters, *killas*) and the Ministry of Land (for registration and settlement of land). In CDSP II (2000–2005), two were added: the Department of Agriculture Extension (DAE, focused on introduction of suitable cultivation technologies and crop varieties) and the Department of Public Health Engineering (DPHE, installation of tube wells and latrines). In CDSP III (2005–2011) the Forest Department (planning and implementation of several kinds of tree plantations) brought the number to six, the same as in CDSP IV (2011–2017). Currently the project is in a bridging period (to the end of 2021) toward a fifth phase. In all phases, BWDB acted as the lead agency. These departments have representatives at the various administrative levels, from national down to Upazila level.

In newly created chars, a gradual increase in the presence of the government can be observed. In the very first stages, the government is totally absent. Staff of the Ministry of Land (land registration and land settlement offices) are the first to appear, soon followed by colleagues from the Forest Department. Over time they are usually joined by personnel from infrastructure oriented agencies as BWDB, LGED and DPHE.

NGOs always formed part and parcel of the overall framework, with changes in their contractual position in the different phases. In CDSP I local NGOs were employed for few specific mobilization activities. In the subsequent two phases, the input of a national NGO was based on a contract between the donor (represented by the Royal Netherlands Embassy), with subsequent contracts between the national and local NGOs, while in the fourth phase, the local NGOs were contracted by the technical assistance team. The range of involvement was broadened to eight fields: health and family planning, micro-credit and capacity development, water and sanitation, legal and human rights, homestead agriculture, fisheries, poultry and livestock and disaster management. All these activities complement the inputs of the government agencies.

As soon as it is established to which administrative unit the new land belongs, local government institutions as the Union Councils, Upazila Councils, and to a lesser extent District Councils begin to play a role. At household level, the first institutions are usually, as mentioned earlier, the *samaj* and religious institutions such as mosques- and *madrassa*-committees. With the emerging presence of government, certainly in cases of projects as CDSP, a number of new community organizations are introduced, giving shape to the concept of participation. The most significant ones for the project are the Water Management Groups (especially in areas turned into polders, planning and monitoring of water management infrastructure, routine maintenance), the Farmer Forums (focus groups of crop agriculture extension services, role in distribution of adapted technologies), and the Social Forestry Groups (planning, implementation and maintenance of plantations). The NGOs are supporting the formation of all-female NGO groups (focused in savings and skills training, including homestead agriculture) and Tube well User Groups (see Abedin et al. 2011; CDSP IV 2018c).

It would require a separate chapter to properly present and analyze the elaborate network of bilateral connections and multi-institutional coordination among all parties involved. In brief, the Inter-Ministerial Steering Committee (national, Secretary level, policy-oriented) and the Project Management Committee (agency level, Project Director level, implementation-oriented) play key roles in the coordination. At field level, agreements exist between various groups and government agencies, supplemented by ongoing bilateral consultations. The project as a whole was supported by a technical assistance team, consisting of a consortium of foreign and local consultants, with over the years a gradual shrinking of the foreign input. Contribution of the Bangladeshi consultants to the planning and execution of project activities have been considerable and is often undervalued. Coordination with other development efforts in the area, in particular with regard to fisheries and livestock, that proved to be very fruitful, came about through initial consultations between the technical assistance teams of the projects.

Socio-economic Transformation in Charlands

What has been the ultimate impact of the CDSP interventions on the livelihoods of the char settlers, did they fare better economically and how was the social position affected, both of men and women? The bulk of economic benefits for the households stem from the increase in agricultural production. As explained earlier, cropping intensity was dramatically higher (from 115 to 200 and more after about ten years). At the same time many farmers shifted from traditional rice varieties to high yielding ones. For aman rice, a doubling in yield from 2 to 4 tons (and even more) per hectare was not uncommon. Families invested more in their own homesteads, resulting in more fruit and vegetable production. Forestry development has proven to be a source of modest additional income, with the benefit sharing agreements of the social forestry approach. Though wild fisheries were hampered by the construction of polders, aquaculture showed a huge potential for the settlers.

The investments in public infrastructure definitely had a considerable positive impact on economic opportunities. Through the network of roads settlers could sell produce to other areas, while goods and services could be procured from beyond their own communities. Markets were developed all over the chars, often by local initiatives. Traders and middlemen, with links to the capital city Dhaka and other big cities, came to the new areas, generally leading to higher prices for char products sold elsewhere and lower prices for imported goods as fertilizer and seeds and processed articles as groceries and medicines. The uptake in economic activities led to subsequent effects such as the establishment of banks; workshops were erected and the need for transport increased, all leading to employment opportunities for char families.

In the chars, the same trend can be observed as in other areas of the country, which is a shift toward diversification of income. Households derive income not only from practicing farming, but also from non-agricultural activities. In coastal chars, this is still not so much a luxury as a dire need. For many families, food insecurity is still a major issue. Difficult periods of the year are November/December when rice stocks get depleted, and July/August, with low demands for labor. Circumstances force settlers to look for other sources of income. This is the reason that many men migrate seasonally to cities like Feni and Chittagong for employment as daily laborer.

The thrust of CDSP's interventions lay with the construction of infrastructure and economic development, less so with the provision of social services. But infrastructure created an indirect link with, for instance, education. In the chars, primary schools are usually established by initiatives of the settlers themselves, in absence of any presence of the Education Department and without any further outside help. Teachers are members of the community and the school runs on contributions from the people themselves. Cyclone shelters are used as school buildings and are being designed with the school function in mind. As far as the issue of health, the supply of drinking water and latrines had obvious benefits. The same can be said of the opportunities of an improved diet by diversification of food sources and increased availability of protein and vitamin rich food (fruits, vegetables, and fish). Provision of health care services remained weak in the chars, especially in the remote areas. It should be noted that NGOs were involved in socially oriented activities on family planning, hygiene education and human rights.

The overall impact of the multidisciplinary CDSP program was a significantly altered socio-economic scenario (see Abedin et al. 2011; CDSP III 2010). In a few words, it can probably best be described as communities facing less natural hazards and other vulnerabilities and enjoying more security in a number of ways. In a physical sense, settlers benefitted from flood prevention, drainage improvement, cyclone shelters, and a much better law and order situation. The increase in economic production and employment opportunities contributed to more economic security, supported by the legal security of land titles. The formation of community based groups, in particular the Water Management Organizations, brought more social cohesion. The land titles gave the settlers control over a key natural resource. This offered space to shift the focus of their struggle to obtaining their fair share of water resources and to equity in sharing the benefits of public lands. The social position in relation to other stakeholders was much strengthened by the increased self-confidence and cohesion among the households.

Their participation in field-level institutions proved to be an avenue for women to enhance their ability to speak up. Their share in control over land (women signed land titles) and access to and use of economic opportunities instilled self-confidence, leading to more influence in public life, but also at home. The stronger economic position and improved social status resulted in greater mobility and contributed to a reduction in divorce rates and abandonment. On the whole, female empowerment in coastal chars was served by the project's interventions (Abedin et al. 2011; CDSP IV 2018a).

A lot of positive developments can be observed, but not all original benefits proved to be sustainable. Evaluation of the impact in the very first CDSP areas showed that in practice in a number of cases control over land had been fragmented due to distribution of land among siblings in the same household. Autonomous population growth and immigration increased pressure on production factors and social services, watering down initial advantages. Having said this, the poverty rate (40% very poor households) continued to be much lower than before the activities started (90% in the same category). The conclusion seems justified, that the inhabitants of previously remote areas moved out of the periphery and got (re)integrated with the larger Bangladesh society.

Reflections—Looking Back and to the Future

Based on its overall results, the CDSP model can certainly serve as an example for future char development programs. It contains essential elements of integration and participation, and indeed contributed to a greater security and reduction of poverty of char settlers. In particular ensuring land titles to the new migrants was a crucial move, contributing to the many positive outcomes.

As experiences to date demonstrate, the economic benefits, mostly generated in agriculture, are considerable. Post-project cost benefit calculations, based on actual costs and benefits during the last phase of CDSP, point to an internal rate of return of around 20%, dependent on different scenarios over a period of 20 years (CDSP IV 2018b). The environment could however be made more enabling in order to further enhance efficiency and effectiveness of char programs.

In order to safeguard the coherence between future interventions, a regional plan for the Meghna estuary and surrounding areas should be developed, ideally within the framework of the Bangladesh Delta Plan 2100. Such a plan should include a land use plan for the whole of the estuary and projections where land accretion and erosion will occur. A regional plan should identify areas where studies have to take place to assess the feasibility of char development programs and where measures could be taken, as for instance, cross dams, to stimulate land accretion. In addition attention has to be given to areas where mangroves can be planted to help formation and stabilization of new land, as well as to serve as protection of the coastline.

Experience has shown that there are a number of complications in the period after new land has been formed. During the twenty years that this land belongs to the Forest Department, illegal occupation takes place often. Uncertainties emerge about the jurisdiction. Land offices do not have the capacity to regularly update the status of chars, leading to conflicts regarding which administrative unit (Districts, Upazilas) has authority over the new land. The situation calls for a specific policy pertaining to the period between land accretion and the initiation of official allocation of the matured land to people or institutions. The Ministry of Land should apply in the whole country the shortened and more transparent land settlement procedure introduced under CDSP. That has not yet happened, but encouraging signs are that the Ministry of Land has the intention to establish a new Department for Char Development and Settlement. Furthermore, the introduction of a Digital Land Management System is a declared prime target for the Ministry, while the settlement of government *khas* land has been identified as a poverty reduction program.

Although the insights on climate change are permanently evolving, the main characteristic of the climate scenario for Bangladesh that can be expected are: a warmer and wetter climate by 2050, an increase in rainfall during the monsoon with a more erratic pattern, increased flows in the Ganges–Brahmaputra–Meghna river system, more and more severe cyclones, a higher frequency and intensity of droughts and higher sea levels. Especially in the central part of the coastal zone in which the Lower Meghna area is located, these characteristics bring with them the risk of more often and extensive flooding and an accelerating intrusion of the salinity front (see Chap. 11).

It should be highlighted that the present policy and political environment for further development of coastal chars is encouraging, as is evident in the Bangladesh Delta Plan 2100, approved by the National Economic Council in September 2018. With a view on the consequences of climate change, the government decided to develop a long term plan. BDP 2100 seeks to integrate the aspirations of Bangladesh to become an upper middle-income country, with a longer-term integrated and holistic vision of sustainable management of water and land resources. The plan document consists of separate volumes on strategy and on investments (GED 2018a; b). Throughout the strategy part, ample attention is given to coastal issues, ranging from threats such as cyclones and salinity intrusion to opportunities as the "Blue Economy" (sustainable use of natural resources of the sea and ocean).

For the future of char development, especially interesting are the topics of integrated spatial planning, coastal land accretion and the optimal use of coastal land. For char development, relevant proposals in the list of investments are efforts to reclaim land by construction of cross dams, the continuation of CDSP in a new phase, an integrated reclamation and development project south of Hatiya and further studies on the morphological dynamics of the Meghna estuary, in particular related to the stability of chars. In light of uncertainties such as climate change and socio-economic developments in the country, the plan rightly stresses the significance of adaptive, flexible strategies. Such an approach requires strong institutions and a broad and reliable database. Institutional and knowledge development are therefore overarching priorities for the future.

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Chapter 23
Livelihood Development in Coastal Chars in the Meghna Estuary: The Danida Experience

Harvey Demaine

Abstract Dynamic hydro-geomorphology in the Meghna Delta has resulted in southward movement of the Noakhali district coastline, creating successive chars, adding 1800 km^2 of new land. These chars offered new opportunities for livelihood of poor people, many of whom have lost their former lands to riverbank erosion. The char stabilization and development programs were designed to adapt to the specific environment and the needs of resource-poor households in the chars. This chapter focuses on the experience of successive Danida-funded projects in fisheries and livestock in livelihood development of poor households in the Noakhali coastal chars. Particular features highlighted are: the inclusion of poor households in value chains, emphasis on low-input culture systems; the Farmer Field School approach; the importance of community-based organizations and links to local agribusiness for input and market access. Lessons learned from the experience are underscored, the need for harmonization of activities between the Danida and other projects to ensure sustainability is stressed, and the approach is compared to other recent projects in the Delta.

Keywords Meghna estuary · Char formation and settlement · Livestock and fishery programs · Poverty reduction and sustainable livelihood · Danida programs · Bangladesh

Introduction

The Meghna estuary is a highly dynamic hydro-geomorphological system, involving a simultaneous process of riverine erosion and accretion, which, together with construction of cross-dams and embankments over the last 60 years, has created a succession of chars and the coastline has moved south some 60 km adding some 1800 km^2 to the land area. These chars have offered new opportunities for livelihood of poor people, many of whom have lost their former lands to river bank erosion.

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Typically, it takes around a decade after accretion that coastal chars become sufficiently consolidated for permanent human settlement and they often shift location with time (Carvajal et al. 2011). In the initial stages of stabilization, extensive livestock rearing and various types of capture fisheries are the key sources for livelihood. Later, with further consolidation and empolderization, under projects like Char Development and Settlement Project or CDSP (see Chap. 22), these options slowly decline with transition to different forms of animal husbandry and to aquaculture in place of fisheries.

This chapter briefly reviews the transition in the role of fisheries and livestock in the livelihood of coastal char communities from extensive systems to more conventional animal husbandry and aquaculture. It then turns to the experience of successive Danida projects in fisheries, livestock, and related sectors to improve the livelihood of rural poor in the coastal chars of Greater Noakhali district as a possible model for sustainable development. The Danida programs were expanded in the CDSP chars for enhancement of income and livelihoods of the new settlers. The important role played by the harmonization and twinning of activities between the Danida projects and those of CDSP and other organizations is also highlighted in this chapter.

The Context and Methodology

The chapter draws on the personal experience of the author as Advisor to the successive Danida projects on fisheries and livestock development, implemented in Noakhali from 2003 to 2013. The reports and studies prepared by Danida Project staff and those by CDSP, particularly CDSP IV Baseline Surveys (2011–2018) on the "new chars" have been used as background materials for the study and to derive lessons learned from the experiences of coastal char settlement and livelihood programs. The five new chars are Char Ziauddin, Char Nangulia, Noler Char, Caring Char, and Urir Char (Fig. 23.1).

CDSP was a settlement project while Danida designed a program for development of the agricultural sector in Greater Noakhali (and also in Patuakhali and Barguna districts). Both CDSP and the Danida programs had geographic overlap, common development philosophy and close cooperation, although the Danida programs were not involved in resettling people in chars. Danida's work in Noakhali and the wider southern coastal region from the late 1990s began as a sectoral project in aquaculture, then expanded to animal husbandry and it was the decision of the Regional Fisheries and Livestock Development Component (RFLDC) Project Management to widen the scope of the intervention to homestead gardening. The main focus became the development of a sustainable extension approach in support of the improved livelihood of poor rural households through the fisheries and livestock sectors.

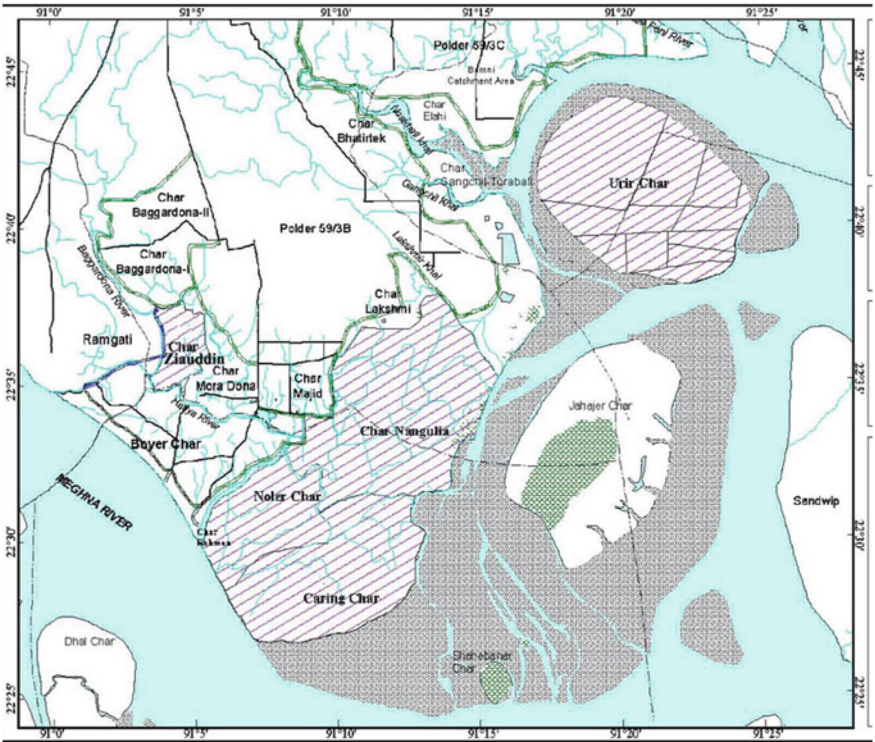

Fig. 23.1 Areas under the "New Chars" of CDSP Phase IV (*Source* CDSP IV (2013))

Livelihoods During Char Consolidation

Livestock[1]

The earliest livelihood subsystem to develop in the coastal chars is extensive grazing of ruminant livestock. As the char stabilizes and is colonized by grasses, people with capital and influence move, sometimes literally ship, large livestock, (buffalo, cattle, and sheep) to the chars. This grazing system is known as *batan* or temporary shelter. In Urir Char, the least consolidated of the new chars, in 2008 there were 55–60 buffalo bathans, 50–55 cattle bathans and 18–20 sheep bathans. In all cases, a typical bathan ranges from 30 to 300 heads of cattle, 50–200 of buffalo and 100–200 of sheep. In Urir Char, around 75 individuals own these bathan*s*, half of them from powerful and rich in the island chars and/or main lands in Noakhali district. Similar goalbathan systems are found in charlands in the Brahmaputra–Jamuna floodplains (Zaman 1988, 1991). A few smaller bathans are managed by several families in

[1] Materials for this section are largely from the study by Ahmed et al. (2008).

partnership. Most bathan*s* have their own *killa*, a raised mound on which animals can be gathered for protection against tidal surges and can be fenced at night time.

As the chars are colonized by individual migrant households, the smaller bathans may shift to the *borga* (shared) system. In the unempoldered chars like Urir Char and parts of Char Nangulia, an estimated 60% of cattle rearing households and 30% of goat rearing households rear the animals according to this system, the equivalent of share cropping in crop cultivation. Under the system, comparatively richer persons buy cattle, goat, and sheep and give these to poorer persons to tend. Male calves are typically sold in 1–2 years, while heifers are used for milk and calf production. The proceeds of the rearing are shared between the owner and the person in charge of rearing. For example, in the case of milk cows, the milk and the first calf are retained by the person who is responsible for rearing—most often a woman—who also receives 50% of the subsequent calves. The cow then remains with the investor and when sold, he receives the profit.

Fisheries: Livelihood on the Margin Between Land and Sea

Fisheries livelihoods during the initial colonization of the coastal chars depend, among others, on the socio-economic background of the settlers. Most of the migrants moved from islands of the Meghna estuary, especially Hatiya, where many were previously involved in various fishing occupations. At least, some seek to maintain such occupations in their new chars.[2] Three different kinds of fisheries may be recognized in the new chars: the inshore fishery, focused on the iconic *hilsa* and *chewa*, a goby mainly dried for fish feed; shrimp and prawn post-larvae catching; and crab catching. In most instances, the fishing operations are run by better-off households who own boats and may have shifted their operations from the islands. They typically employ crews of up to 10 fishermen from poorer households and, in the case of *chewa,* teams, largely of women, who sun-dry the fish on the chars (AgroMech 2009). Although the boat owners are better-off, they are frequently dependent on the so-called *dadon*—an informal system of credit as cash advance, which ties them to particular traders and results in price deductions.

The second two categories are essentially coping strategies adopted by poorer households. It has been estimated that in 2007 as many as 11,500 people were involved in post-larvae catching in Char Nangulia, Noler Char, and Caring Char in 2007 (Alam and Moniruzzaman 2007a, b, c). The fishing is by set bag nets in the shallow waters and again the catchers are often dependent on *dadon* from local hawkers to buy and replace their nets. Women are estimated to make up 30% of the catchers, mainly during the day, when they are accompanied by their out-of-school (girl) children. Such fishing is considered illegal, but may contribute incomes of between Tk.5000–10,000 per year from the two crops for *Bagda* and *Golda.* Crab

[2] Although there is some evidence that access is also constrained by the movement of the main fishery further offshore, south of Hatiya, as a result of the climatic/geomorphological changes.

catching is a relatively new occupation in response to international market demand; it has become common in Urir Char where the catchers are typically temporary migrants from Sandwip, Companiganj, and Maijdee and ship to markets there (Ahmed et al. 2008).

Transition to Aquaculture and Mixed Systems

It is well known that increasing population pressure and environmental and institutional changes affect access to traditional livelihood resource systems in the coastal zone. The process of empolderization of the coastal chars of Noakhali has added to this process, preventing the movement of fish from the estuary and blocking streams inland. In these circumstances, the "catch per unit effort" in the wild fishery steadily declines and, to maintain their supplies of fish, families need to invest in rearing fish, i.e., in aquaculture. Observation of this process shows that it is a slow, but steady transition through systems, which are a mixture of capture and culture to culture alone. The feasibility studies of the new chars in Noakhali show this transition both between the more and less protected chars and between households with a different resource bases in those chars (Alam and Moniruzzaman 2007a, b, c; Demaine 2011a, b).

Development of the Fisheries and Livestock Systems in the Protected Chars

Resource Potentials

Once the coastal chars are stabilized/protected, aquaculture and animal husbandry development have considerable potentials. In the fisheries subsector, the majority of households in the coastal chars dig ponds near their homesteads to create their house platform and gradually develop these into productive assets. As Table 23.1 shows, before they were protected in 2012, almost all households in the new chars had ponds and over half were culturing fish to some extent. The table shows, however, that there was considerable variation between the chars largely as a result of the propensity to flood, poor water retention capacity and, in the case of Urir Char, the difficulty of obtaining the necessary inputs. In addition, successive government and donor-funded projects to develop the chars have created many formal settlement villages, variously termed *Ashrayan, Abashan,* or cluster villages, excavating community ponds at their center, initially for domestic use, but with potentials for aquaculture. Demaine (2013)

Table 23.1 Characteristics of household fish culture in new chars

	Char Ziauddin (N = 100)	Char Nangulia (N = 600)	Noler Char (N = 300)	Caring Char (N = 300)	Urir Char (N = 100)	All (N = 1400)
HH with pond/ditch (%)	92	97	91	81	96	92
Culture pond/ditch (%)	47	62	42	25	84	51
Type of culture (%)						
Traditional culture	81	80	82	53	54	75
Semi-intensive culture	16	19	18	47	43	24
Intensive culture	2	1	–	–	3	1
Reason for no culture (%)						
Flooded during high tide	55	67	86	82	62	75
Lack of fingerling and other inputs	6	–	–	–	13	01
Low water retention	31	32	13	18	19	23

Source CDSP (2012)

also identified borrow pits excavated for embankment and road construction as a potential resource for aquaculture.[3]

In the livestock subsector, after conversion to agricultural (crop) land, for some years, agricultural work in the chars is largely confined to the monsoon season (*aman* rice), so that agricultural lands are typically available for grazing of large livestock after harvest. Table 23.2 shows that up to three quarters of households in the new chars in 2013 tended large livestock—for instance, extensive rearing of dairy cattle was prominent in Urir Char (with milk production almost twice the levels of the other areas) and as well as cattle fattening, followed by Char Nangulia. As in the fisheries sector, Demaine et al. (2016) identified that, by creating embankment slopes and Social Forestry schemes, CDSP's development activities offered potential for new fodder resources for livestock rearing.

[3] It should be stressed that these aquaculture potentials are dependent on efficient maintenance of the sea embankments. Changes in estuarine hydrology and rising sea levels due to climate change pose threats to such enterprises as discovered by the writer during a Mission for CDSP IV (2016), which revealed significant erosion of the older dykes from earlier projects in Companiganj and the western coast of Hatiya (see Demaine et al. 2016).

Table 23.2 Profile of large livestock rearing in the new chars

	Char Ziauddin (N = 100)	Char Nangulia (N = 600)	Noler Char (N = 300)	Caring Char (N = 300)	Urir Char (N = 100)	All (N = 1400)
Nos. of HH rearing large livestock	65 (65%)	468 (78%)	222 (74%)	213 (71%)	85 (85%)	1053 (75%)
HH with milking cow (%)	33	42	45	31	67	41
Avg. milk production (Lt))	99	91	118	104	203	114
Avg. income from milk (Tk)	2970	2730	2950	2600	4060	2850
HH with cattle for fattening (%)	28	47	39	28	67	41
HH with goat (%)	10	13	13	28	29	17
HH with buffalo (%)	1	0	1	0	12	1
HH with sheep (%)	0	0	0	0	3	0.2

Source CDSP (2013)

By contrast, in poultry rearing (Table 23.3), almost all households are engaged in the occupation, with some differences in intensity of production and incomes.

Table 23.3 Profile of poultry rearing in the new chars

	Char Ziauddin (N = 100)	Char Nangulia (N = 600)	Noler Char (N = 300)	Caring Char (N = 300)	Urir Char (N = 100)	All (N = 1400)
HH rearing poultry (%)	80	92	82	93	93	89
Fully scavenging (%)	3	0	2	0	0	1
Scavenging plus supplementary feed (%)	97	100	98	100	93	99
Average no. chicken	4	6	5	6	9	6
Average no. duck	7	7	6	6	9	7
Annual production of eggs/in numbers	275	139	127	208	209	156
Income from eggs/in Taka	1210	660	760	1108	1372	817
Annual production of meat/Kg	47	32	26	42	75	36
Income from meat/in Taka	9009	4307	4961	5010	7881	4949

Source CDSP (2013)

From Tables 23.1, 23.2, and 23.3, the overwhelming picture is of low input systems, characterized by extensive fish culture, large livestock grazing, and scavenging poultry and thus low yields and incomes. Given this profile, the key issue for development of both aquaculture and livestock in the consolidated chars was to identify the appropriate interventions for various groups of people with limited resources.

Development of Aquaculture and Animal Husbandry: Institutional Framework and the Role of Danida

Fisheries and Livestock Development in Bangladesh is directed by the separate Departments of Fisheries (DoF) and Livestock Services (DLS) in the Ministry of

Fisheries and Livestock (MOFL). Like many countries in developing Asia, these Departments suffer from constraints on the provision of research, funding and extension services to small-scale farmers, more so in cases of isolated areas like the coastal chars. In these circumstances, aquaculture and livestock development is largely dependent on securing extra resources from donor-funded projects. In both sectors, Danida has been one of the main donors over the last three decades.

Danida's presence in aquaculture and livestock development in the coastal chars of Noakhali began with aquaculture, dating back to 1998 with the establishment of the Greater Noakhali Aquaculture Extension Project (GNAEP) in cooperation with the Department of Fisheries. This project involved promotion of pond polyculture through training of farmers by contracted Non-Governmental Organizations (NGOs), which also provided production credit. In 2002, a similar approach was adopted in the livestock sector under the "Smallholder Livestock Development Project in the Five Southern Districts" (SLDP-2), the same districts covered by GNAEP and its sister project in Patuakhali-Barguna. Simply, all three may be described as top-down, group-based "Training and Credit Projects" derived from the Training and Visit extension model prevalent in agricultural extension in the 1980s.

Greater Noakhali Aquaculture Extension Project

The Greater Noakhali Aquaculture Extension Project (GNAEP) covered all 15 Upazilas (sub-districts) of the three Districts of Greater Noakhali: Feni, Lakshmipur and Noakhali itself. As such, it was wider in its scope than the coastal chars, including, for example, the waterlogged paddy lands of the northern part of the region. However, many of the CDSP chars benefitted from the Danida programs in terms of enhancement of income and livelihoods of the new settlers.

Development of Pro-poor Aquaculture

In technical terms, pond polyculture of Indian major carps best suits large ponds, but with relatively low return. More importantly, despite the stress on provision of credit only in support of the less well-off, the NGOs tended to concentrate on the more creditworthy, better-off households to ensure maximizing circulation and realization of the credit funds. In 2002, however, the opportunity of recruitment of new staff was taken to adjust the extension approach of GNAEP, toward a pro-poor system involving *three linked elements.* The *first* of these was an explicit focus on how the aquaculture value chain could improve the livelihoods of the poor. This was borrowed from the experience of CARE, an NGO in southwest Bangladesh, which had identified the potentials of giant freshwater prawn in the existing farming systems of small-scale farmers. Similar potentials had been identified years earlier in Noakhali (Karim 1989) and confirmed by a feasibility study carried out by GNAEP (Alam

2001). Four areas of intervention were identified and introduced on an experimental basis: (i) integrated prawn farming (IPF), initially in rice fields (*ghers*) in the chars; (ii) use of community ponds for prawn in a mixed polyculture in the settlement villages in the chars; (iii) prawn nurseries in microponds; and (iv) fish drying households in Hatiya. Agreements were made with fishing communities in Hatiya to establish Fishers Associations through which GNAEP arranged credit in place of *dadon*; in return the Fishers Associations ensured that their dried fish (the chewa mentioned above) would be free of pesticide contamination when provided for feed mix to the IPF households on the mainland. Under this arrangement, the fish driers received a better price for their produce.

Linkages with the Private Agribusiness

The *second* element in the GNAEP extension system was partnership with local private entrepreneurs to invest in agribusiness. Originally, the idea of freshwater prawn culture had assumed the provision of prawn seed from the Department of Fisheries, but the Feasibility study (Alam 2001) identified greater potentials in the private sector. Two local businessmen were persuaded to invest in prawn hatcheries. Under similar agreements signed with GNAEP, the project offered the entrepreneurs technical assistance and a market outlet in return for an attractive price and selective credit support to the poor farmers.

Development of Community-Based Organizations

The organization of a new input supply and market value chain was the *third* element of the system created by GNAEP. This was through the promotion of so-called community-based organizations (CBOs), managed by local farmers in the focal areas. Originally only seen as a source of information for the prawn farmers after training, GNAEP realized that they would be more sustainable by acting as the channels for seed and feed supplies from the private sector and ultimately for the marketing of the prawn (and fish) to the processing plants. Also, they provide the project's partner agribusinesses with an alternative to reliance on local informal traders. The CBOs operated on commission (5% of sales value), the profit enabling them to make other investments such as the seine nets needed for the large settlement village ponds.

Regional Fisheries and Livestock Development Component

The "geographically integrated" aquaculture extension system (Gamage et al. 2006) piloted by GNAEP incorporating opportunities in the prawn value chain for resource-poor households in the coastal chars of Noakhali stimulated the adoption of improved aquaculture practices in individual ponds, *ghers* and in community ponds and increased incomes of some 6000 and 7000 farm households. Partly as a result, the pilot strategy was adopted in the design of a further phase of Danida's Agriculture Sector Programme Support (ASPS II), which combined the stand-alone fisheries and livestock projects into a single subprogram, the Regional Fisheries and Livestock Development Component (RFLDC). RFLDC in fact comprised of five different "support units," three at policy level in the Ministry of Fisheries and Livestock and in its two constituent departments and two field level units, in Noakhali and Barisal. The Technical Support Unit (TSU) in Barisal was implemented by the Department of Fisheries, while the TSU in Noakhali, seen as a more terrestrial environment, was carried out with the Department of Livestock Services.

Field School and Training

At the same time, in the context of its programmatic approach, Danida sought to extend its well-respected Farmer Field School (FFS) training methodology from its traditional focus in the crops sector to Integrated Fisheries and Livestock Farmer Field School. Local youths, with good contacts and communication skills and respect among community members, were recruited and trained as Local Facilitators (LFs), who were employed by CBOs as their field staff. There was strong focus on practical orientation and learnings conducted at field levels covering the whole homestead agriculture system with an emphasis on food security and nutrition. A set of six different modules in aquaculture, poultry, small livestock (e.g., goats), cattle fattening, vegetable gardening, and nutrition were offered, keeping in view greater resilience against environmental shocks. In addition, RFLDC trained technical persons in the CBOs to conduct vaccination and other veterinarian services for the farmers, women as Poultry Workers (PW), and young men as Community Livestock Workers (CLWs).

Adaptive Research

The Farmer Field School in poultry had resulted in a reversion to the focus on indigenous breeds of livestock. This had emerged from adaptive research in SLDP-2 aimed at reducing the complexity and therefore increasing the sustainability of the ertwhile popular Bangladesh Poultry Model (BPM) (Sarkar et al. 2006). Surprisingly, poor women described the BPM system, with its minimum investment, as "high risk." This was taken into account in the inclusion in the design of RFLDC of funds for adaptive research, which were especially important in the livestock sector.

In the livestock sector also, the CBOs' role was not confined to vaccination services but extended also to supply of young stock, chicks, ducklings, and in a very few cases calves of local cattle breeds. The most notable of these enterprises was the development of a number of duckling hatcheries based upon the rice husk (*tush)* incubating technology. RFLDC had identified duck rearing as an occupation of considerable potential for the region, both in the chars and in the waterlogged paddy lands of northern Noakhali; however, the government duck hatchery at Sonagazi was unable to satisfy local demand for day-old ducklings (DOD) because its market system involved considerable mark-ups. After consideration of other alternatives, (Ali and Khan 2007), RFLDC determined that the Rice Husk Hatchery system, operated through the CBOs was the most promising option. A *farmer* consultant was hired and CBO members trained. This and other initiatives eventually led to establishing Producer and Marketing Groups (PMG) setting up examples of the CBOs role toward community-level agribusiness in the later phase of RFLDC. An outstanding example of this trend was the organization of a group of seven CBOs in Subornachar who came to an agreement with a market trader to sell chicken and duck eggs to the markets at Chaumohani and Maijdee (Faruq 2012).

Learnings from Danida Experience

Building on the above description of the development processes in the coastal chars in Noakhali, we may summarize and identify a number of key learning points (for details, see Demaine and Huque 2013). First, participatory learning through field school training provided opportunities to poor farmers and women in the chars to learn new technologies, facilitating production diversification, creating employment, and improving income, food security, and nutrition. Second, supported by adaptive research based on local knowledge, the income and livelihood programs allowed flexibility to meet the specific needs and resource base of the farmers. This ultimately ensured wider community participation and contributed to empowerment of women in the chars. Third, the Danida technical and institutional approach linked farmers' learning programs with local government institutions and private agribusiness with positive impact for fisheries and livestock development. Fourth, unlike many other externally funded projects, Danida's technical and participatory project framework created a sustainable extension system through RFLDC that extended into a new phase of Danida's Agricultural Growth and Employment Program (AGEP). Finally, the CDSP (Chap. 23) benefited from this technical and participatory framework in its hitherto limited aquaculture and livestock activities under the Social and Livelihoods Development Program in the coastal chars.

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Part VII
Char Administration and Governance

Editors' Note

In a number of preceding chapters of the book, several authors have raised issues regarding access, and use of new charlands. Existing legal framework on alluvial land concerning char land administration and governance, with legacies of the past, has been conducive to occupation of newly emerging charlands by the locally powerful landowners, largely from the mainland. The current volume has reiterated the need for a new policy/legal framework and establishment of a dedicated institution for charland administration and governance to ensure rights of the char people and those displaced by recurrent erosions.

Mohammad Zaman and Akhtar Hossain describe the historical evolution of the Bengal Alluvion and Diluvion Regulation (i.e., A/D Regulation 1825) within the colonial/post-colonial, administrative and socio-cultural contexts for control of charland by the locally powerful zamindars and wealthy landowners. The authors are of the view that legacies of the A/D Regulation 1825 continued through the subsequent amendments of the law in post-independence Bangladesh. The complex set of rules in the current laws, intricacies of survey, records and ownership/titles of newly emerged land ultimately favor the powerful landed elites. Using ethno-historical and village-level data related to land survey, records and titling, The authors demonstrate how the poor and landless, who deserve to be the beneficiaries of new land, lose out to the locally powerful landed elites. They call for a paradigmatic shift in replacing the age-old legal framework and settlement policy by one that is conducive to the welfare of contemporary char dwellers in Bangladesh.

Atiur Rahman's reflective overview provides further justification for a more inclusive char development strategy. Rahman reports significant differences between the quality of life in char and non-char areas in terms of access to school, medical/health facilities and credit sources. Besides, coverage of the public social safety net was found very limited and inadequate for the char dwellers. In addition, relative physical isolation of the chars, lack of connectivity and periodic displacement and migration by char people remain major barriers to poverty reduction in char areas.

With all of the above in mind, there are strong reasons for rethinking char development issues with a new set of laws and institutions that can benefit the char dwellers. Such an agenda must rest on the rights of the char people and anchored to the principle of administrative devolution and local participation.

Chapter 24
The Charland Administration and Governance: Need for a Paradigm Shift

Mohammad Zaman and Md. Akhtar Hossain

Abstract The charland in the riverine flood plain and the delta was historically viewed as isolated and lawless "frontiers," yet the land was productively used in terms of extension of cultivation through migration and development of new settlements in Bengal. The first legislative enactment by the British colonial rulers—the *Bengal Alluvion and Diluvion Regulation* (1825)—aimed at granting out leases of waste land for cultivation in order to raise revenue and settling boundaries of estates with local *zamindars* to avoid conflicting claims over depositional lands. The regulation itself and subsequent amendments in 1950 (East Bengal State Acquisition and Tenancy Act) and more recent post-independent presidential order of 1972, the ordinance of 1975, and the act of 1994 are a complex set of rules that indeed provoked more conflicts than actually settling ownerships and titles. This chapter provides an overview of the evolution of the legal framework and examines key administrative issues related to charland survey, use and ownerships, and settlement in contemporary Bangladesh. Since erosion and accretion of land and human settlement on such land will continue in the riverine areas of the country, improvements in the existing legal framework, settlement policy, and economic development of the char people remain imperative in the given context. It is argued in this chapter that a paradigm shift is called for in realizing the potentials of development in the charlands of Bangladesh.

Keywords Alluvion and diluvion land · Char frontiers · Charland administration · Legal framework · Settlement policy · Paradigm shift

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Introduction

This chapter discusses the historical context of the use and settlement of charland, and its evolution and complexities in contemporary Bangladesh.[1] Two previous chapters (Chaps. 4 and 22) briefly touched upon these critical issues, calling for new legal framework and establishment of dedicated institutions for char development. A more ethnographic account of erosion and accretion of land as well as a detailed review and analysis of laws governing charlands in post-independent Bangladesh are presented in this chapter. Also examined are the intricacies of survey, records, and ownership of newly emerged land and how the poor and landless, who are the intended beneficiaries of new land, lose out at the end to the locally powerful landed elites. It is argued that a paradigm shift—both in policy and administration of charland—is necessary for more effective management of charlands and to improve the socio-economic conditions of the char communities in the country.

The chapter begins with a broad ethnographic account of the dynamics of erosion and accretion, causing displacement and miseries among the char inhabitants. This is followed by a brief description of the evolution for settlements in these new char "frontiers" for agriculture and settlement and the development of alluvion and diluvion laws for charland management during the colonial period. Third, an analysis of the legacies of the colonial era laws in post-independent Bangladesh reveals that the charlands are up for grab by the powerful landowners while the char dwellers struggle to make a living using the new land resources without any legal rights or tenancy. Finally, a set of recommendations dealing with improvements in the existing legal framework, settlement policy, and administration of charland is presented for charland administration and betterment of the char communities.

The Context

Charlands in Bangladesh constitutes an estimated 8% of the total land area of the country. The multi-channel braided and meandering river systems of the country, with their historic shifts in courses, gradual or sudden, have eroded many villages along their bank lines in the past and continue so doing, thereby creating and re-creating numerous chars in the process of erosion and accretion. Thus, river bank erosion is a long wave of disaster, which appears to have heightened within the

[1] The discussion and analyses presented in this chapter are derived from extensive ethnographic research by Zaman on disasters and displacement in the Brahmaputra-Jamuna floodplain (Zaman 1988). For many years, Zaman's core research has been on char settlements, economies, and social organizations and how these have historically been shaped by the colonial and post-colonial land tenure systems and administration with regards to alluvial and diluvial land (Zaman 1991). Hossain, a former Settlement and Survey Officer and Deputy Secretary to the Government of Bangladesh, has many years of experience with land laws and administration and lately worked on land acquisition and resettlement issues involving bankline and char lands in the Brahmaputra-Jamuna and Padma floodplains.

context of climate change impacts. However, the crisis faced by the char dwellers today is not entirely consequences of climate change as many would tend to argue. The chars and the char dwellers in the country have been part of the landscape and heritage. The chars rise from the riverbeds, which are largely made up of river deposition, erosion, and re-deposition. The changes due to erosion and accretion in the large river systems also change the landscape of the country; as a result, as one observer puts it: "there is nothing like an up-to-date map of Bangladesh" (Mydans 1987). These changes have influenced human settlements and the way of life of the people in the Bengal delta since time immemorial, reflected in folk songs, stories, and novels. Mention may be made in this regard of the classic work of the famous litterateur, Manik Bandyopadhyay (1936), the *Padma Nodir Majhi* (The Boatman of the Padma), which portrays the colonization of new chars in the southern delta.[2]

Unfortunately, there are no official statistics on chars in Bangladesh. As per the web sources (https://en.wikipedia.org), there are only 37 island chars in the Bay of Bengal. These are of course large, long-established, and settled islands—for instance, Bhola Island, the largest in the country; others mentioned include Char Mantaz, Dublar Char, Urirchar, Sandwip, Manpura island, Kutubdia, Maheshkhali, Sonadia, Char Faizuddin, and so on (see Chap. 9). There are, however, many more not in the list—for instance, now famous Bhasan Char[3] in the Bay of Bengal. Many of the new islands are uninhabited and typically remain so until they are stable and above the normal flood level; however, they are productively used during the dry season by people from the mainland and surrounding chars. Every year thousands move from the overcrowded mainland to try and scratch out a living in the island chars. It is because the poverty-stricken households and seasonal agricultural laborers migrate temporarily to these newly formed chars that death tolls in recent tropical storms and cyclones have been so high, despite improvements in the early warning systems, preparedness, and construction of shelters along the coastal belts (Zaman 2020).

The land in the floodplain is, thus, an unstable resource—just like a "gamble" in the shifting river channels. As a result, in any given year, thousands of acres of land are either lost or gained in the Jamuna floodplain (see Chap. 8). There are few riverine areas in the world that have such unstable river courses (Coleman 1969) leading to bankline erosions annually. However, what disappears ultimately reappears (not always in the same location), leading to accretion of new lands, called chars, as new resources for survival. In most instances, the newly accreted charlands are

[2] Manik Bandyopadhyay (1908-1956), one of Bengal's most prominent writers, narrates the story of a group of poor fishermen of a small village on the bank of river Padma and how they were used by an enigmatic person named Hossain in colonizing an island called Moynar Char off the coast of Noakhali District. This novel was included in UNESCO's collection of India's best representative works. The novel was translated into English by Mukherjee (1977), and Painter and Lovelock (1977).

[3] The Bangladesh government recently spent over US$300 million to transform this 20-year old uninhabited island char to a secured and planned settlement for relocation of 100,000 Rohingya refugees. The relocation of refugees slowly started in December 2020 despite stiff opposition from international/humanitarian agencies on safety grounds due to periodic tropical cyclones (see Zaman 2019a).

immediately put to use as much as possible by people from neighboring chars or mainland. Thus, the new chars become "frontiers" for agriculture and livelihoods. Today, upward of an estimated 20 million people live in chars in Bangladesh.

The Rise of Char Settlements in the Delta Frontier

Knowledge about geography of the Bengal delta is of a relatively recent origin. Prior to Rennell's survey (1781), there is very limited reliable description of the geography of the country (see Chaps. 4 and 9).[4] Mukerjee (1938) noted that the first settlement of Bengal was in the old alluvium tracts, and the interior was more or less a region of marshes and wastes devoid of habitations. This section briefly discusses the historical processes within which the frontier had begun and how **it** developed in the riverine delta. The shifting river channels not only caused loss of land and human settlement, they also opened up "frontiers" of new agricultural land supported by what may be called a "frontier-type" society—isolated, marginal, often violent**,** and culturally distinct from the mainland (see Chap. 2).

As noted earlier in Chap. 2, one can identify two different processes of colonization of new land historically: (i) land reclamation, clearing, and cultivation, especially in the Sundarbans and (ii) claims over newly accreted or depositional land by peasants in the riparian areas of the active river systems (Hunter 1875, Pargiter 1885). According to Pargiter (1885:1–3), Tilman Hanckell, then judge and magistrate of Murli (now Jessore) submitted a plan in 1783 to Warren Hastings, the Governor General of British India, for granting leases of waste land for cultivation in order to raise revenue and to settle boundaries of their estates with local *zamindars*. Hunter (1875) also reports that *zamindars*, in order to extend their untaxed domain, introduced their tenants (*abadkari* or reclaiming *raiyats*), who led the clearing of forests and reclamation (also, see Gupta 1940).

Settlement and ownership rights over accreted land in the active river system also raised similar legal problems as in the Sundarbans, which was further complicated by the fact that there was always more than one claimant of the new alluvial land, as it is often difficult to ascertain the ownership of such new land—for instance, (i) whether it belongs to the estate to which it may have been annexed; (ii) or to some other riparian proprietor upstream who lost his land due to erosion; (iii) or even to people on the other side of the river. As a result, people from both banks of the river quickly become involved in dispute over new land, which may even end in bloodshed for the disputed land. In the riparian areas, writes Carstairs (1885), the initial step in establishing ownership rights in new char land is to get "possession." Bengal landlords, notes Carstairs (1885:274), had always maintained a disciplined "band

[4] However, in some classic texts of ancient India—for example, the *Rig-Veda* (latter half of second millennium B.C.) and *Mahabharata* (second century B.C to second century A.D), the country of *Vanga* is mentioned, which corresponds roughly to the oldest portion of present day Bengal (see Majumdar 1971).

of retainers" who would fight or use force for possession over newly accreted land "especially on the banks of the Ganges… or in its delta, Backergunj [Bakerganj, now Barisal] or Fareedpore [Faridpur] not without loss of life." Carstairs (1885:242–243) explains the entire process in the following words:

> Men would go with boats or carts to cut whatever produce there was – trees, grass, or anything – to stick up sheds, to dry fishing nets, or perform any other act of ownership they could think of; grazing cattle, ploughing etc.… A rival party would arrive from the other side with similar intention, and pitched battles often ensued. For a newly formed island, though next season might see it swept away again, might also become a rich estate, of good land.

Carstairs (1885) also mentioned that such fighting was often aided by hired bravos or goons, and *lathiyals* (see Mukerjee 1938, Broomfield 1976). Zaman (1991) presents a comprehensive socio-economic and political analysis of the rise of the *lathiyali*—a system of patronage relations between landlords and peasants in the floodplain—in colonizing charlands during the *zamindari* period (1793–1950) in Bengal. Zaman (1991) further maintains that the relative isolation of chars and their simultaneous integration with the colonial state through a chain of landed intermediaries (such as *zamindar*, *talukdar* and *jotedar*) with a monopoly administrative and political power that gave rise to this parapolitical system. This scenario involving possession of new land and conflicts between rival parties is more or less true for the active riverine and delta areas of Bangladesh even today. The selective use of violence by local *jotedars*, who act as patrons of the *lathiyals*, works as the ultimate arbitrator of dispute over new charlands (Zaman 1987). The *lathiyali* situations have changed now, however, disputes over new chars often lead to violent clashes between disputing parties involving both char and mainland people.

Alluvial and Diluvial Land Policies: An Overview

AD Policies 1825–1971

All alluvial and diluvial lands formed either by gradual or sudden shift of river courses were excluded from the Permanent Settlement Act of 1793 (Gupta 1940), largely due to uncertain nature of land formation in the riparian areas, difficulties in determining rights over the newly accreted land, and perhaps lack of a clear idea of the liability of assessed or fixed revenue for land lost in the process of diluvion or erosion. This proved advantageous to the local zamindars who took all possible steps and brought additional land into their untaxed domain using reclaiming raiyats. The first legislative enactment by the state for regulation of disputes concerning alluvion and diluvion land was the Bengal Alluvion and Diluvion Regulation XI of 1825. Traditionally, ownership and dispute over alluvion and diluvion land were decided following standard loca1 usage of *lapta payosti* (addition to existing land) and *sikosti* (reformation in situ or on original site). The intents of the enactment of 1825 were to provide legal basis to these generally known rules and "as well as for the guidance of the Courts of Justice determining claims to lands gained by alluvion" (Kabir 1961:59).

The Regulation of 1825 (section 4/1&3) provides three different interpretations of ownership based on the nature of alluvial formations: (1) Land gained by gradual accretion and deposition was allowed to be owned by persons to whose riparian estates the accretion land had annexed (i.e., *lapta payosti*); (2) Sudden erosion of land which afterward reappeared on the old site or very close to it (i.e., *sikosti*) and properly "identified" should be the property of the original owner and not be considered an increment to the estate to which it may have annexed; (3) Charland or an island that arose in the midst of a river where the channel between it and the river is not wide enough shall be under "direct management" of the government and that the government may settle it with any person it considers proper (Gupta 1940; Kabir 1961). However, the modes of proof or identification made the task more complex and apparently difficult. Gupta (1940) and Raskhit (1979) reported many legal and practical difficulties in settling disputes and enforcing law. As new islands surfaced above the water level, new struggles also arose to occupy them, and legal battles have been known to go on for decades or even generations. Local riots and violence over newly accreted land were common, and typically local zamindars were involved directly with such rioting (Gupta 1940). The alluvial land, thus, remained subject to perennial dispute, recurring riot, and protracted litigation due to difficulties in identifying whether the land is an accretion or a reformation in situ. It was largely in consequence of local turbulence and rioting in connection with accretion of land that prompted the government to pass the Bengal Alluvial Lands Act in 1920, which allowed the collector of the district to take control of disputed land, until the claims were legally settled (Gupta 1940; Khan 1977).

The principle of the regulation of 1825 was retained by the East Bengal State Acquisition and Tenancy Act (EBSATA) of 1950 with only two limitations on the restoration of land lost by diluvion to the previous owners (Ali 1980; Siddiqui 1980). The period, during which such restoration can take place, has to be within 20 years. Such restoration was, however, subjected to the provisions laid down in the EBSATA (1950/sections 20&90)—i.e., land to remain in the possession of the rent receiver, and the cultivating *raiyat*) and limitation of transfer of holding up to a maximum of 125 acres. The regulation (1825) itself and subsequent amendments to 1950 are a complex set of rules which provoked more conflicting claims than they may have actually settled (Gupta 1940; Raskhit 1979).

Post-Independence Developments (1971–): Who Benefits

Immediately after independence in 1971, the government led by Sheikh Mujibur Rahman adopted some popular land reform measures for the benefit of the poor. The presidential order of 1972 (Numbers 72, 135, and 137) extinguished all rights of *maliks* (tenants) on new accretion land traditionally enjoyed for nearly 150 years since the first enactment in 1825. The order provided that all newly emerged charlands previously lost by diluvion would now be vested absolutely in the Government of Bangladesh. The primary objectives were to recover all such land from the clutches of the locally powerful land grabbers and to make available more land for redistribution among the landless and poor peasants (Siddiqui1980; Ali 1980). The 1972 order also clearly mentioned that in settling newly accreted land, preference should be given to landless families, and those displaced by river erosion provided that the total ownership together with the new land held by a family not exceed 33 *bighas* (8.3 acres). There were provisions for co-operatives and "cluster" village schemes for the poor and landless. The Mujib government did not make much headway with the implementation of the new char land legislation.

The 1972 legislation also came as a sudden threat to the traditional rural power base of the large landowners on two grounds: (i) they legally lost control over any future accreted land and (ii) the possible mobilization of the landless and displaced people to form co-operatives and cluster villages posed threats to their local power and control. In order to appease the large landholders after the political change in 1975, the new military government made two major amendments (Ordinance LXI of 1975) to the original law. The amendment stated that the owner of the land lost by diluvion is eligible to settlement of the new char/*khas* land. The qualifying ceiling for eligibility was raised from 33 to 100 *bighas* (8.3–33.3 acres). The two amendments strengthened the hands of the landed elite with opportunities for further legal manipulation and ultimate deprivation of the landless and displaced peasants from having access to depositional land (Siddiqui 1980).

Further amendments were brought by the Act of XV (1994) which provided the owner(s) of the land diluviated will have access to the re-formed land in situ if it appears within 30 years, subject to the ceiling of 60 *bighas* (20 acres). The owner meanwhile must pay rent, and certificate from the revenue authority would be required to claim the new land. If the land re-emerges after 30 years, the land will be vested to the government. The huge gap of 30 years in effect helps the locally powerful to grab newly emerged land prior to survey and settlement.

Survey and Records of Charlands: Pitfalls and Perils

A fundamental problem with charland administration is undue and excessive delays in survey and settlement of new depositional land. This is largely due to the centralized settlement operations by the Director General of Land Records and Survey (DGLRS) located in Dhaka. Under the current system, periodic settlement operations are carried out, if at all, every 10 or 20 or even up to 30 years (Ali 1981). Delays and/or lack of settlement surveys work for the benefit of the local land grabbers because "possession" (*jore jar jomi tar*/might is right) remains a crucial factor in the eventual determination of ownership. A new char, once it has stabilized, become a target for encroachment. Typically, groups of landless families are moved on to the char by powerful and wealthy landowner, who provide support and shelters and use the landless laborer as permanent labor for cultivation; they are also patron-tied dependent *lathiyals*, when required (Zaman 1991).

The DGLRS is responsible for cadastral surveys and maps for land, while the deputy commissioner (DC) of the concerned district is responsible for land lease and settlement. For char lands, the standard practice is to draw an alluvion and diluvion line annually, following the flood season to mark the extent of erosion in the area; however, this is rarely done. Typically, at the request of the DC, a party consisting of *ameen* (land surveyor) and other staff is deputed by DGLRS for cadastral survey (CS) and records, which is locally called Diara settlement and survey operation. The tasks of Diara settlement are to prepare maps of the newly emerged land, prepare plots, list of owners, and areas considered *khas* (or government land) for lease by the DC as per law to landless people directly or groups for cluster/model village resettlement**.** However, when the survey team arrives after 10 or 15 years of accretion of the new chars, those who use and/or control the newly emerged lands by force become owners over others through fictitious records completed in collusion with corrupt local revenue officials. Under such situations, the settlement and survey operation camps in the field turn a "game played by money" ("*takar khela*"). Zaman (1988) reports endless grievances against survey operations in Kazipur chars; local influential brokered "transactions" to keep their records of rights straight. The survey officials took money from all disputing parties and promised "fair" records. The officials always perform tricks, often demanding papers that the displaced char people were unable to present (Zaman and Wiest 1985). Zaman (1988:145) remarked that the survey party "literally plundered the villagers (*deshe ashle jarip, proja hoy garib*/when the surveyors come, tenants become poorer)" and robbed them off despite their precarious situations.

The DC plays an important role in land management and administration in Bangladesh. He is at the top of land administration hierarchy in the district. The DC is supported by an additional deputy commissioner (ADC/Revenue). The DC is the land rent collector, who also manages the *khas*/government land and acts as the custodian of the land records for the district. The DC has assistant commissioners (ACs/Land) under him, who look after land in respective upazilas. The AC/Land and local *tehsildars* (land revenue staff) to support him. The function of the AC/Land is mainly to supervise rent collection, update land ownership record, and manages khas land.

The allocation of *khas* land in the char is done by the DC through committees in upazila and district levels. The upazila committee scrutinizes the applications and recommends and district committee approves allotments. However, the process lacks transparency, as it lacks representation from char/displaced groups in the committees. The lack of information and disclosures about the meetings, applications, and allotments is key hurdles to the "hard-to-reach" char people. Many landless char inhabitants cannot afford to buy a "landless certificate" from revenue officials. As a result, fake applications submitted by wealthy and powerful people are entertained. The local officials and public representatives influence decisions and outcomes in favor of their applicants with corrupt practices. In sum, delays in char land surveys and complexity of records, coupled with bureaucracy in resettlement of new depositional land, breed grounds for such corruption in survey and resettlement.

Resettlement of erosion-affected or displaced char people has never been a top priority of the government of Bangladesh. In the past, programs such as *Ashrayan Prokolpa, Adarsha Gram* Project, and *Guchchhogram r*esettled at various phases a mix of landless and homeless families, climate victims/displaced, and members of vulnerable groups, which also included erosion victims. According to available sources (https://www.ashrayanpmo.gov.bd/; Mallick et al. 2019), many projects are now underway in the country for the resettlement of homeless and landless people; however, these are not dedicated programs to help erosion-displaced households. As a result, hundreds and thousands of erosion-displaced households still live on embankments in various parts of the country (see Zaman et al. 2019). The government of Bangladesh recently announced an allocation of Taka 10.0 billion in the 2019–2000 budget for rehabilitation of families displaced by erosion in the country (see Zaman 2019b). This surely is a welcome step, though the initiative may prove too small in dealing with the huge and complex issues involved in riverbank erosion, displacement, and resettlement.

Why a Paradigm Shift

As evident from the above discussion, the problem in charland administration stems largely from delayed and fictitious land survey records. This "business as usual" approach breeds corruption both in survey and resettlement. Therefore, the age-old legal framework to regulate charlands for survey, identification, and ownership rights aimed at leasing and revenue collection *must* be replaced by an entirely new set of laws and institutions for the benefits of the char people. This will require a paradigm shift with a new legislative agenda upholding the rights of the char people and those displaced by erosions.

The new paradigm must be anchored on the principle of administrative devolution and local participation. The current system of centralized and periodic survey and settlement operation must give way to more frequent and regular survey based on local needs related to erosion and accretion. Currently, there are no accurate data nationally on the extent of erosion induced displacement, migration, and resettlement. Riverbank erosion as a disaster should be assigned a national priority. The loss of land and displacement results in poverty and marginalization of a large segment of rural population. A GISbased data collection system and database on the extent of erosion, displacement, and resettlement should be instituted in dealing with erosions and chars. This data should also be used as guidelines for assistance and rehabilitation.

The complexity of the causes and the dynamics of river erosion is not well addressed in the current approaches to disaster management in Bangladesh. For instance, while there is a standard operating procedure (SOP) for flood responses in the country, there is no such SOP to respond to and assist the river erosion displacement. Erosion victims rarely receive any assistance from local administration or support from Disaster Management Bureau.

Chars have great potential, given appropriate and renewed attention with focus on long-term sustainable development strategies, anchored in new institutions, policies, and good governance. The first National Char Convention[5] of 2015, which was attended by more than 1200 people (half of them char dwellers) called for char development with a 14-point declaration that included demands for proper infrastructure, health care, education, safe drinking water, skill development/livelihood support, mainstreaming gender in char development, social safety net program, new land laws for mainland chars, distribution of khas land to genuinely poor char dwellers, and a national char foundation to strengthen the development of char communities and to formulate a char development policy. In this regard, the experiences and "lessons learned" from the chars livelihoods program (Chap. 20) and other experiments in island chars in Gaibandha (Chap. 21), and those in the Meghna estuary (Chaps. 22 and 23) areas, which improved livelihoods of over a million extreme poor households, should be instructive.

The displacement and suffering experienced by the char people and the complexities associated with their responses are challenging. A new national policy and a dedicated new institutional focal point such as a char development authority may be established with a mandate for planning, management, and development of chars much like the haor development in Bangladesh. The authority or a directorate dedicated to char development is also urgently needed in view of the Bangladesh Delta Plan 2100 to manage river erosion disasters and to provide the means for displaced persons to secure a better life. The state of Assam in India, which has a large char area in the upper Brahmaputra valley, manages char development programs through the directorate of char area development, established primarily to improve the socio-economic conditions of char/*chapori* areas through affirmative and inclusive development approach (https://dircad.assam.gov.in/about-us/citizens-charter-0). The CLP and other experiments in Bangladesh char development already established solid grounds moving forward with new ideas, laws, and institutions that require for a paradigm shift to improve the socio-economic conditions of people living in the island and coastal chars in Bangladesh.

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Chapter 25
Discourses on Char Development in Bangladesh

Atiur Rahman

Abstract Bangladesh is one of the most vulnerable countries in terms of climate change challenges in the world. The accelerated frequency of climate events has already brought the issue of riverbank erosion into the forefront of policy landscape. Consequently, the issue of char development has gained significant policy traction, especially during the last decade or so. The Bangladesh Delta Plan (BDP) 2100 and other studies have identified that land accretion caused by silt deposition is significantly lower than the loss of land due to riverbank erosion. This provides necessary and sufficient reason for taking the challenge of bank erosion in both macro- and micro-level discourse on char development more seriously. A household moving to char areas after losing its homestead due to riverbank erosion is most likely to have significantly lower living standards than it used to enjoy prior to displacement. Yet, riverbank erosion victims are forced to move into these areas, as they have no other options. The government has prioritized char development and the related riverbank erosion issues in its long-term climate change management plan as reflected in BDP 2100. However, these policy commitments are yet to be fully translated into duly financed long-term development programs. Infrastructure support and resilience enhancing initiatives, if strategically combined, can ensure sustainable riverbank erosion management leading to greater reduction in extreme poverty.

Keywords Riverbank erosion · Climate change · Bangladesh development plan · Infrastructure development · Resilience · Char development programs

The Context

The latest Global Climate Risk Index 2020 by ‘Germanwatch’ ranked Bangladesh as seventh among the countries most affected by extreme weather events during the period from 1999 to 2018 (Eckstein et al. 2019). The report states that during this

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period, Bangladesh experienced 191 extreme weather events costing the country over 577 losses of life and almost USD 1,700 million in property damage. These events also reportedly resulted in 0.4 percent loss per unit GDP. Indeed, the effects of climate change are predicted not only to severely affect the lives and livelihoods of the people in disaster prone areas, but also dampen the macroeconomic growth prospect of the economy as a whole. Moody's investors service projected early this year that Bangladesh is most likely to be subjected to material credit risk due to sea level rise and related shocks (The Daily *New Age*, 17 January 2020). The 2020 floods in the middle of the ongoing Covid-19 pandemic have further accentuated that downside risk.

A UNICEF report published in March 2019 identified climate change as a long-term threat for Bangladesh that may further accentuate riverbank erosion in the country affecting lives and livelihoods of the people living in riverbank areas—for instance, a village on the bank of the Brahmaputra in northwest Bangladesh lost one-third of its surface within the last decade (Ingram 2019). The report further states that riverbank erosion alone displaces from 50 to 200 thousand people from their homesteads annually in Bangladesh (see Chaps. 8 and 9). Victims of riverbank erosion most often have no alternatives but to settle in nearby charlands (Sarker 2003). Some, of course, become climate refugees and migrate to the cities.

The char development issue has gained significant policy traction recently, especially over the last decade. The first ever National Char convention was held in June 2015 where char people from all over the country, policy makers, development organizations, and civil society representatives participated and expressed their concerns and commitments to work in a collaborative manner to address the char development issues/challenges effectively and sustainably. Top policy makers, including the honorable speaker of the National Parliament, reemphasized the need for necessary policy attention to address the special concerns of the char dwellers (NCA 2015). Fortunately, many of these commitments have been aptly reflected in the Bangladesh Delta Plan 2100 (BDP 2100). BDP 2100 also noted that accretion of new land in the form of chars is significantly lower compared to loss of land due to riverbank erosion. This implies that if the riverbank erosion victims continue to have no alternatives but to settle in char areas, then population density in remote char areas will keep on increasing, resulting in further intensification of the challenges of lives and livelihoods in those areas.

In view of the above, it is necessary to take into consideration the riverbank erosion challenge in the macro- and micro-levels of char development discourse. In this context, this paper intends to discuss the current socio-economic conditions of char dwellers, analyze the policy environment related to char development and riverbank erosion, discuss some exemplary char development initiatives, and finally, based on these discussions, present a set of way forward, which may contribute toward further incorporation of the riverbank erosion challenge and related issues in future development planning.

Developing Char Lives: Learning from Experiences

Riverbank erosion victims living in char areas face numerous challenges and are forced to live with severe uncertainty. They have, however, learned to cope with the challenges through innovation and complementary interventions implemented by relevant national agencies and national/international NGOs. It has been demonstrated that when provided with necessary opportunities to develop their human capital base, the char dwellers are better placed to diversify their skill-sets and, hence, depend less on vulnerable livelihoods (Blitz 2014).

Char development initiatives in Bangladesh have gone well beyond ensuring access to basic social services (e.g., health, education) for char dwellers and are now focusing more on enhancing their resilience. For example, just over a decade ago in the northwestern district of Gaibandha, agriculture dependent char dwellers used to become helpless during the *monga* seasons (i.e., dry five months) that followed the monsoon season. They could not cultivate any crop because the char land would get sandy. Practical Action Bangladesh began a program that promoted cultivation of pumpkins by the char dwellers during the said period of the year (see Chap. 21; also, SWFF 2019). The program has been promoting sandbar cropping and assisting thousands of char dwellers in using this technique to cultivate pumpkins. This provides a sustainable income for the char farmers. And also it ensures supply of a nutritious vegetable for the ever-growing market. The respective local government bodies have also been collaborating with this program by allowing the char farmers to cultivate on the land which they do not own legally. Currently, nearly 40 thousand char dwelling farmers produce 600–1200 pumpkins per family annually (SWFF 2019).

Stakeholders from both public and private organizations are becoming increasingly aware of the need for improving the conditions of the char dwellers, along with the potential macroeconomic gains from doing so. Swisscontact-Bangladesh, a non-governmental initiative, has been implementing one such project titled 'Making Markets Work for the Jamuna, Padma and Teesta Chars (M4C).' This project identifies the potential of char areas to become significant zones of value-added agricultural products focusing on improving the underperforming market system. M4C aims to realize the potentials of the private and public actors, so that they invest in the char areas as well as provide services leading to enhancement of economic performances of the poor char households (Swisscontact 2018). As of 2018, the project was working with 650 service providers to promote 25 services related to agro-input supply and production services, agro-output market, and financial services. Till the end of 2018, the project reached over 54 thousand small holder households, and over 11 thousands of these had increased annual net income. A core factor for the success of this project was the involvement of the government and private sector actors in both enhancing supply of agro-inputs and in channeling the agricultural produce of the char farmers to the rest of the market.

Bangladesh government, together with the government of the Netherlands and IFAD implemented the char development and settlement project (CDSP), a four phase project starting from 2011 and completed in 2018 (see Chap. 22). The final phase of the project aimed to secure livelihoods of 28 thousand households residing in five char areas adjacent to northeastern district of Noakhali. To do so, the project focused on ensuring protection from climate change effects through water management and forestry, building resilient infrastructure, land settlement and titling, providing livelihood support, and providing technical support to six government implementing agencies. The key to the success of this project has been identified as the effective collaboration between the PNGOs and several government implementing agencies closely involved in the project (CDSP 2018).

The chars livelihood program (CLP), which lasted from 2004 to 2016, was perhaps the most significant char development program implemented (see Chap. 20). This program saw collaboration between the government of Bangladesh (Rural Development and Cooperatives Division) and multiple international development partners (UKAID and DFID). Local NGOs contributed in implementing the project in char areas covering around 10 northwestern districts. Almost 70 thousand char households graduated from abject conditions due to the support provided by this project. The project leveraged contribution of private sector actors to ensure sustainability of the gains and develop partnerships with 76 small entrepreneurs. The government also came forward to provide khas land to many of these beneficiaries. CLP took a holistic approach to char development in the context of the pressing need of resilient livelihoods and reduction in the vulnerabilities that the extreme poor char dwellers face (CLP 2019). It has provided ample evidence to infer that if all the stakeholders work together utilizing their comparative advantages, then it is possible to sustainably improve the lives and livelihoods in char areas of Bangladesh (Pritchard et al. 2015).

Comparing Quality of Life

Riverbank erosion victims eventually migrating to vulnerable char areas are subjected to significant loss of income and hence living standards. While short-term socioeconomic impacts of the displacements include loss of home, agricultural land, jobs and assets, and long-term ones include deteriorated living conditions and indirect impacts on human health and development (Das et al. 2017). This has been found to be true for the coastal char areas as well as those in the northwestern parts of Bangladesh. Because of geographic location, the coastal char areas are subjected to frequent natural disasters such as floods, river erosion, cyclone, tornado, hailstorm, water logging, and salinity intrusion. And all these affect 70 percent of agricultural income and sources of livelihoods (Rahman et al. 2015). Northwestern char people are also subjected to frequent floods and river erosions. Two-third of their earnings is decreased due to natural disaster, and this limits their ability to recover from the shocks (Hossain et al. 2018). Char people in Bangladesh have been found to be more vulnerable to effects of climate change compared to the rest of the country. The core factors working behind these higher vulnerabilities are their livelihood sources and access to food, water, and health care (Alam et al. 2017).

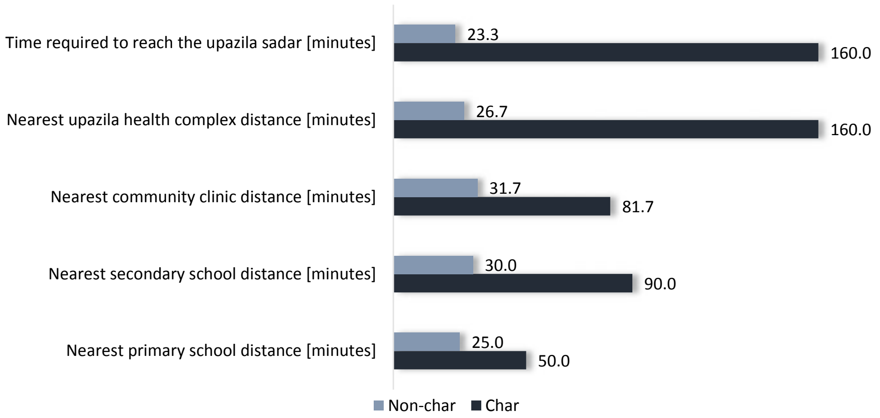

Fig. 25.1 Comparison of access (i.e., time taken) to different services for char dwellers and rest of the country. *Source* Data from the HIES 2016 report of BBS

To compare the living conditions of the char dwellers with those living in non-char areas, this data were used from three upazilas of Bangladesh that have significant char areas: Kurigram Sadar Upazila[1] (Kurigram District), Sirajganj Sadar Upazila (Sirajganj District), and Dashmina Upazila (Patuakhali District). Levels of access to different services were measured simply in terms of time required to go to the nearest service point for those living in char areas and those living in non-char areas.

Figure 25.1 shows that while on average a char dweller has to spend almost three hours to go to the nearest urban center, the average time required for a non-char dweller is below half an hour. In order to reach nearby healthcare facilities, the char dwellers need 2.5–6 times as much compared to the non-char people. This difference is similarly visible in terms of access to education facilities. These comparisons based on national statistical reports clearly indicate a significant gap in terms of quality of life. It is to be noted that such data from other areas may vary significantly due to locational diversity.

Brief qualitative surveys were conducted in the three upazilas mentioned above to better comprehend quality of life issues in chars. In addition, a number of service providers in those areas were interviewed, using regular KIIs methods. Those who lost their homesteads migrated to chars as no other option was available to them; some moved to live on the crowded flood control embankment. Only rarely erosion affected households could afford to live on rental houses or arrange for migration to cities. The data indicated that 70% of the households migrating to char areas could not maintain their previous income level. Many of the farmers became day laborers or transport workers. As there is very little scope for non-farm income generating activities in char areas, working age household members normally migrate to urban areas in search of work, at least for a couple of months every year.

[1] For administrative purposes Bangladesh is divided into 64 districts, each of which is comprised of multiple sub-districts known as Upazilas.

Access to social safety net programs (SSNPs) was found inadequate even in non-char areas. Hence, when households fell victim to riverbank erosion and applied for SSNP support, they were not likely to receive that social protection service. It was found that MFIs were providing credit support to many households in char areas. However, their service penetration in these areas was also significantly lower compared to that in the mainland. Major barriers on the way of further expansion of MFI operations in char areas are: (a) lack of connectivity; (b) relatively higher operation cost and risk; (c) lack of confidence among char dwellers in repaying; (d) propensity to migrate; (e) lack of supply of credit.

In the char areas within the selected upazilas, a number of NGOs are implementing programs on non-farm income generating activities, thereby contributing to the betterment of lives and livelihoods of char dwellers. However, the outreach and coverage of these programs are not adequate in meeting actual demand. For instance, difficulties in obtaining education in char areas were identified as a significant barrier to employment and income opportunities. Many parents in char areas marry their daughters off at an early age as continuing their education may be more arduous, including other social factors. While most char dwelling parents currently try to send their children to primary schools, a much lower share of them are likely to send them to secondary schools. Another critically important issue here is frequent loss of school infrastructure due to flooding and riverbank erosion. A survey conducted by concern worldwide has revealed that there were 92 primary schools in the survey area, whereas at least 155 were needed (Ali 2015). Furthermore, only 45% of the existing primary schools in those areas had conducive learning environments. The concern worldwide survey also reported that only 28% of these schools had safe drinking water and sanitation facilities.

Like education, access to health care is also very inadequate for char dwellers. Most of the char dwellers resort to multimodal traveling to go to the nearby healthcare facilities. As a result, they have to spend more time and money to seek healthcare services. Consequently, despite the national MMR being reduced significantly over the last two decades, the primary health condition situation in char areas remains dire. Khalequzzaman et al. (2015) reported that 66% of the char dwellers were preferring traditional treatment over the kind provided by formal healthcare facilities.

During the rainy season, there is little or no work available in the char areas. So, a large number of char dwellers migrate to cities looking for jobs, staying away from home for a long period. Due to lack of access to other services (like education and training and even proper information), these seasonally migrating char dwellers are generally forced to engage in low paying activities in the urban centers. They have only limited non-farm income generating opportunities available to them. A survey conducted recently by Unnayan Shamannay has revealed that just over one-fourth of char dwellers had adequate access to these income generating opportunities (Rahman et al. 2015).

Another critical issue raised at the KIIs was access to land ownership both among char dwellers and non-char dwellers who are likely to lose land due to riverbank erosion. Majority of char dwellers do not legally own any land, including their homesteads. The newly emerged char lands are categorized as khas land by the government until the lands are surveyed and records prepared define ownership and/or redistribution of khas land to landless households as per the provision of the law. This, however, rarely happens in the char areas (see Chap. 24).

In sum, there are plenty of empirical research-based evidences that are compatible with these findings and thus establish linkage between the twin issues of river erosion and low living standards in char areas. All this implies that any micro- or macro-level initiatives to improve lives and livelihoods in char areas must take into account the scale of river erosion and its potential impact on the socio-economic conditions of the affected households. Otherwise, the gains from many years of development programs may all be lost due to just one incident of significant river erosion. This has huge implications for the sustainability of development for this vulnerable population.

The recent outbreak of COVID-19 across the country and the subsequent slowing down of the economy also has severe implications for the lives and livelihoods of the char people. Char households, who are mostly reliant on agriculture for income, are likely to be among the most affected. A point to be noted here is that poverty and extreme poverty rates were already higher (compared to national averages) in char areas- implying the economic effects of the ongoing slowdown will be more severe in those areas compared to rest of the country. Consultations with development organizations working in char areas have further confirmed these fears.[2] They have pointed out that the pandemic-induced economic slowdown is affecting the char economy in two ways. On the one hand, the char farmers are finding it extremely difficult to market their products because of the disruption in supply chains. And, on the other hand, many of the char household members who were working in the cities currently have low or no income and hence are unable to send money back home as they used to. According to these development practitioners, more or less 80% of the char households have become further vulnerable due to this situation. And all of these households will get thrown back to abject poverty (households with no assets at all) if this situation continues for a few more months.

Char Development: Public Policy Landscape

The general economic division (GED) of Bangladesh planning commission under the ministry of planning has developed the Bangladesh Delta Plan 2100 (BDP 2100)2100. This plan has been prepared in view of addressing long-term challenges of climate change and natural hazards. It seeks to integrate the medium to long-term aspirations of the country to become an upper middle-income country (UMIC) by eliminating extreme poverty within the coming decade and becoming a developed country by the following decade. It intends to achieve these goals through managing water, ecology, environment, and land resources in the context of their interaction with natural disasters and climate change.

[2] The author consulted with NGO personnel implementing char livelihood programs through two focus group discussions.

BDP 2100 identifies the morphology of the rivers of the country to be highly dynamic and riverbank erosion as a regular phenomenon (see Chaps. 8 and 9). It also predicts the strong possibility of increased riverbank erosion in future. This, in the said plan, is attributed to the changes in the river flow and sediment transport due to multi-faceted impacts of climate change (see Chap. 11). In this context, the plan identifies riverbank erosion control as one of the top five investment priorities for Bangladesh during this century.

The plan considers char protection and development issues/challenges under its flood risk management strategies. It has two sub-strategies specifically focusing on char areas: (i) the first sub-strategy for equipping flood management and drainage schemes for future (sub-strategy FR 2.1) prioritizes management of 'submerged char' before taking any initiative for flood management and river flow management; (ii) the eighth sub-strategy for safeguarding livelihoods of vulnerable communities (sub-strategy FR 3.8) prioritizes protection of char and its population along with alternative livelihood arrangements. This implies that Bangladesh has rightly identified the need to prioritize the management of riverbank erosion and char livelihood protection in its long-term planning agenda. The government appears to have adequate policy commitments to take into account the effects of riverbank erosion and their impact on lives and livelihoods of the char dwellers. On the one hand, the BDP 2100 intends to direct adequate investment to sustainably control the riverbank erosion. And on the other, it suggests to specially address the needs of the people who are most vulnerable to riverbank erosion (i.e., those living in the char areas). It is most important that these commitments be reflected in the soon to be finalized eighth five year plan (FYP) of the country.

While the government policy documents such as the BDP 2100 duly prioritizes char development and riverbank erosion control as key development concerns, public expenditures (i.e., allocations in the national budgets) during recent years do not reflect these priorities. Of the 132 programs/projects under the social safety net programs of the government during FY 2018–19 and FY 2019–20, only two have been directly focused on char development. The first one is a special cash transfer program that covers char areas as well as other vulnerable areas, and the second one is a development project in the annual development program (ADP). The combined allocations of these two programs for the last two fiscal years stand to be just over USD 27.3 million and USD 33.2 million, looking quite inadequate for the tasks—not even half of a percentage point as shown in Table 25.1.

Table 25.1 clearly indicates a lag in translating the policy commitments into adequately funded actions. More importantly, the special funds allocated for char development are not being spent, because there is no dedicated agency or institution responsible for char development activities and/or use of the allocated resources for char people.

The National Char Alliance (NCA), a platform comprised of like-minded development partners and development organizations focused on improving living conditions of the char dwellers, has identified three major policy priorities that need to be addressed effectively and efficiently to meet the lives and livelihood challenges of the char dwellers (NCA 2015). Firstly, establishing a char foundation/board to

Table 25.1 Social safety net allocations for projects/programs directly related to char development

		Allocations (million USD)	
		FY 2018–19	FY 2019–20 (Proposed)
1	Special assistance for the development of char, Haor, and underdeveloped areas	24.0	6.0
2	Char development and settlement	3.3	27.2
Total allocation for char and other vulnerable areas		27.3	33.2
Total SSNP budget		7728	8924
Share in total (%)		0.35	0.37

Source Budget Documents, Finance Division, MOF, Government of the People's Republic of Bangladesh

ensure sustainable development of char people. This will work as the institutional authority for char development, inclusive of disaster management in char areas. The National Budget allocations for char areas can be spent effectively if there is such an institutional arrangement. Secondly, developing specific development projects for char areas. So far, no specific projects have been undertaken to ensure poverty eradication and sustainable development of char areas through providing health and education services, meeting food and nutrition demands, creating employment, developing skilled human resources, increasing agro-production, and managing disasters. To attain the SDG targets, specific development projects with such objectives are needed. Finally, formulation of a National Char Policy. At present the government does not have a comprehensive approach toward the development of char people with clear objectives of poverty eradication, social safety net, disaster management, education services, women and child rights preservation, land use, agricultural development, crop marketing, and social awareness. Thus, there remains a significant gap in the policy landscape.

While the NCA proposals rightly prioritize the development concerns of the char people, it must also be noted that these are only broad policy directives and require further granularity taking into account the possibilities and frequencies of riverbank erosion. For example, the proposed central coordination body (be it a foundation or a board or some other type of entity) must have flexibility in terms of its area of jurisdiction and the capacity to collaborate with other development partners. As char areas are subjected to regular riverbank erosion, the number of people living in these areas is likely to vary from one year to another. Moreover, the locations of chars may also change from time to time due to riverbank erosion and subsequent land accretion. Additionally, the level of public–private cooperation may vary from char to char, depending on the intensity of the disaster. In brief, it can be said that the government of Bangladesh has prioritized char development and river erosion issues in its long-term climate change management plan. However, these policy commitments are yet to be translated into duly financed development programs. The civil society actors and the NGOs working for development of char areas have identified key policy barriers to comprehensive and sustainable solutions of the challenges faced by the char dwellers. Coordinated actions are required from both the public and private sector actors, in accordance with long-term policy directives based on prior experiences of implementing development initiatives in char areas, for achieving the desired goal. Too many suggestions going round in circles.

Taking Chars into Account: What Needs to Be Done

The government of Bangladesh has consistently prioritized the issue of char development in its policy discourse. Due to the advocacy of civil society platforms like the NCA and the effective complementary support of development partners, the government should immediately come up with a comprehensive set of medium- to long-term implementation plans to translate the policy commitments into viable programs and projects. It is also to be recognized that these policies need to incorporate concerns related to riverbank erosion management into the medium- to long-term char development strategy and/or action plan (Fig. 25.2).

There should be more flood control, and bank protection works as part of the infrastructure development project for erosion control and char stability as contained in the BDP 2100. Other infrastructural supports such as enhancing connectivity or access to electricity also need to be ensured. A key point to be noted in this regard is that river erosion victims are at the risk of unplanned river flow and/or flood management endeavors. Those displaced by river erosion usually end up moving from one char area to another, constantly trying to avoid losing their economic gains to natural disasters. Infrastructural interventions can ensure a decrease in riverbank erosion, or at least control the extent of damage done. However, resilience enhancing endeavors are equally important. On the one hand, there should be adequate initiatives

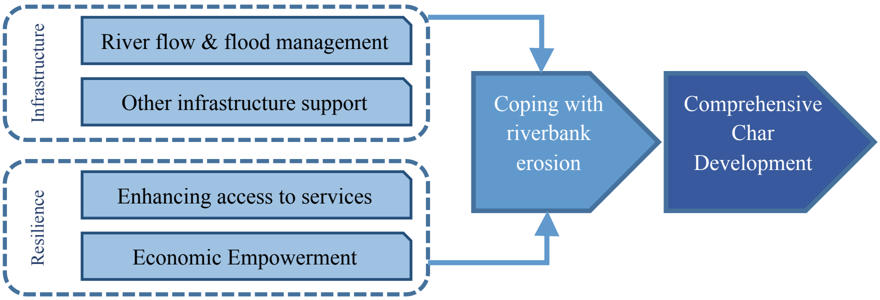

Fig. 25.2 Incorporating river erosion management into comprehensive char development strategy. *Source* author

to enhance access to different public and private services for realizing the socio-economic potential of the char dwellers. Economic empowerment through creation of further sustainable income generating opportunities can enhance the resilience to shocks. As a result, households falling prey to river erosion in the future will be better prepared to cope with these shocks. To this end, private sector participation, i.e., market-led solutions are indeed equally significant.

Combining infrastructure support and resilience enhancing initiatives can ensure sustainable riverbank erosion management. Hence, these need to be incorporated into any char development strategy, be it an advocacy action plan to gain policy traction for char development or a long-term comprehensive char development plan. Thanks to the proliferation of ICT and digital connectivity, the age-old remoteness of the people living in chars has been removed to some extent. These people now have access to mobile phones and financial services, leading to higher level of social and economic connectivity. They can now project their needs to both the local and central governments, leading to better public attention. As a result, they are receiving some public services like schooling, community clinic support, and social protection services to some extent. They are also receiving services like solar street lights, solar irrigation pumps, and tele-medicines. However, the average level of extreme poverty in char areas remains more than double the national average and calls for focused policy attention from the government.

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Part VIII
Summary and Conclusion

Chapter 26
Rethinking Char Development in Bangladesh

Mohammad Zaman and Mustafa Alam

Abstract This chapter summarizes the key policy issues derived from the diverse discourses contained in the previous chapters of the book. Lessons learned from the past are made note of in recommending a set of policies for the betterment of communities living in chars within Bangladesh. No national-level database is currently available on chars of the country and the people living there. Besides, a dedicated agency or institution for char development is yet to be put in place. Clearly, the chars represent a unique environment demanding unique solutions. Ensuring land rights for char people and introducing a decentralized and democratic system of governance for them are vital for achieving char development in the country. All this calls toward rethinking char development in Bangladesh.

Keywords Lessons learned from the past · Institution for char development · Land rights for char people · Decentralized administration

Introduction

The rivers and the chars occupy a unique place in the history, ecology, economy, and social life of Bangladesh. A number of experiments on char development in the country over the years, with international aid and assistance—including the Chars Livelihoods Program (CLP) and the char development and settlement project (CDSP) have met with considerable success in contributing to welfare of char people. However, these initiatives covered only limited geographical areas selected from the vast charlands abounding in the floodplains and the delta. Poverty rates are very high in the remote char areas of the country. Char dwellers continue to suffer from limited rights to land and livelihood resources. In sum, the chars have largely been a refuge for displaced in-migrants with no alternative options for survival.

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This final chapter summarizes the key elements concerning the future of char development. It is clear from the materials presented in the foregoing chapters that recognition of rights of the char people over land and resources is essential for enabling development in the chars. Land rights for char dwellers and introduction of a decentralized and democratic system of governance are considered vital for achieving the much awaited socio-economic development in the charlands.

Current Status and Agenda

Lack of National Level Data on Chars and Char People

Charlands in Bangladesh cover an estimated eight percent of the total land area of the country. It is estimated that about 20 million people live in chars. Another 15–20 million people, who live along the banklines of the major rivers, are at risk of displacement by river bank erosion. No national figures are available on the extent of displacement caused by erosion. However, millions have already been displaced over the past decades, a large number of them taking refuge in the chars.[1] Also, resettlement within and in between chars is a common form of adaptation among char villagers.

Also, there are no up-to-date dependable national level data on numbers of char villages/settlements in the country.[2] Available data do not fully or accurately represent the magnitude and complexity of erosion due to (i) endemic nature of erosion and displacement; (ii) periodic migration from one char to another; (iii) poor accessibility in reaching remote char areas of the country. Given this gap in knowledge, collection and compilation of data on charland and its people should be a good start in accounting for the extent of erosion by locations and thereby in assesing the nature of protection and assistance needed by the displaced people.

National Awareness about Erosion and the Chars

There is perhaps no lack of awareness among concerned authorities regarding erosion impacts, displacement, and poverty among people in char areas. However, attempts at erosion mitigation have historically been through large-scale engineering schemes for protective works, with inadequate attention to socio-economic, demographic, and ecological considerations. The flood action plan (FAP) brought chars into the development discourse of the country. An appropriate tenurial system and local economic

[1] A small number, having no option and local support, migrate out of the char areas to nearest towns and cities for employment and livelihoods.

[2] Given the dynamic situation of chars, data available in the decadal census are inadequate and lack accuracy.

diversification would be essential for the welfare of char communities. This was also strongly voiced by the char people at the 1st National Char Convention 2015. The Bangladesh Delta Plan 2100 offers a long-term vision of technical and sustainable social and environmental solutions regarding flooding, erosion, displacement, and migration, which promises to be beneficial to char communities. However, there are lags in translating policy commitments into adequately funded actions and engaging dedicated institutions for delivery.

Limited Recognition of Rights on New Charland

The current legal framework and relevant practices provide limited recognition to the rights of char people on newly accreted land. Following the independence of Bangladesh, the presidential order of 1972 extinguished rights of ownership on accreted land from the powerful landowners to make available more land for redistribution among the displaced and poor households living in chars. The 1975 amendments of the order reverted ownership to the original owners. Further amendments in 1994 allowed the previous owners full access to the accreted land if it appeared within a period of 30 years; if land re-emerges after 30 years, it shall become *khas* or government, land meant for redistribution among landless households. However this huge gap of 30 years in effect helps the locally powerful to grab newly emerged land prior to survey and settlement. In the best case scenario, selected displaced char households were resettled in government-sponsored housing programs such as *Ashrayan Prokolpa* or *Adarsha Gram* Project, along with other landless and climate displaced households, who are largely categorized as internally displaced people.

Lessons from Char Development Experience

The Chars Livelihoods Programmes (CLP) and other char development programs—for instance, Char Development and Support Program (CDSP), Danida's livelihoods programs in coastal chars, Practical Action's Sandbar Technology for agriculture in Gaibandha chars—made significant contributions to social, economic, and organizational developments in char villages. In all these instances, creative solutions were offered, often beyond the confines of local practices and national laws. These initiatives were successful due to beneficiary support and participation, as well as leadership provided by local communities and NGOs involved in the programs.

In the case of CLP, nearly 70,000 char households covering 10 northwestern districts graduated from abject poverty over the two-phases of the programme operations lasting from 2004 to 2016. The CLP took a holistic approach, worked with some of the poorest people in the chars without any assets or titles and brought positive changes in health, housing, income, education, women's empowerment, and social protection, ultimately enhancing their resilience to risks. This external development intervention, aided and supported by development partners, has already led to improvements in char economy and enhanced local capacity. The lessons of CLP can be of help in designing national policies pertaining to char development.

The CDSP is a good example of planned settlement in reclaimed estuarine charlands of Bangladesh. Once such chars have physically stabilized, these are settled by pre-selected landless households, who are provided with land rights/titles, and other infrastructure support, as well as assistance in agricultural development. To date, over 33,000 of landless households have been settled with titles in the four phases of CDSP, which contributed greatly in increasing security and reducing poverty among char settlers in the Meghna estuary. This experience should prove valuable in designing future coastal char development policy for the country.

Advocacy and Mobilization of Char People

The char development interventions have clearly brought some gains in terms of advocacy. This is strongly evident from the *1st National Char Convention*[3] of 2015, which was attended by more than 1200 people, half of them char dwellers from all over the country. The convention was organized by the National Char Alliance (NCA), a platform of NGOs and development partners working in char areas for improving living conditions of the people living there. A 14-Point Declaration was endorsed by the participants for submission to the Government of Bangladesh. The declaration includes demands for proper infrastructure, health care, education, safe drinking water, skill development/livelihood support, mainstreaming gender in char development, social safety net program, proper land laws for chars, and distribution of *khas* land to genuinely poor char dwellers, and formation of a national char foundation to strengthen the development of char communities and to formulate a Char Development Policy. Given appropriate attention to long-term sustainable development goals, anchored in proper institutions and good governance, there is hope for char people and char development in the country.

Maladies of the Old Approach

Three major defining characters of alluvial land derived from the old colonial-era regulations—(i) *payasti* (addition to the existing land); (ii) *sikosti* (reformation in situ or on the original site) and (iii) new deposition in the middle of the river/and or in between channel shall be *khas*/government land—still hold true in the current legislations of the country. The modes of proof or identification of new lands, coupled

[3] *First National Char Convention 2015* (Krishibid Institution Bangladesh, Khamar Bari, Farmgate, Dhaka, 6 June 2015).

with complex legal requirements and/or interpretations thereof make it difficult in settling disputes and enforcing laws. Further, the focus still remains on revenue collection and leasing of char/*khas* lands. In effect, the char people have very little control over the chars.

The current legislations as practiced today favor the powerful landowners and breed malpractices in leasing and redistribution of *khas* land. Additional features of the charland administration include:

(i) Delays and/or lack of settlement surveys work for the benefit of the local land grabbers because "possession" remains a crucial factor in the determination of ownership.
(ii) Endemic dispute over charlands that goes on in the court over generations.
(iii) Displaced char people do not benefit directly from the land and work as tenants, often as "patron-tied" agricultural laborers on the island chars for locally powerful landowners who control the charland.
(iv) The poor households in char communities lack the means and political power to stand up against the vested interests, who control newly emerged charlands.
(v) Since chars are relatively isolated, income and livelihood opportunities there are limited.
(vi) Distribution of charlands as per the alluvial land policy to the poor and displaced families in the chars, particularly in the riverine chars, is a rarity.

In char villages across the country, the poor and the landless are unable to protect their interest against the powerful, who take advantage of and/or manipulate the law to control charland resources to their benefit. This scenario has not changed much in post-independent Bangladesh over the past 50 years. There are compelling evidence that the old-ways have not worked for the benefit of the char people in the country.

Paradigm Shift

For char development in Bangladesh to be worthwhile, it is necessary to go for a paradigm shift based on new institutions, lessons from adaptive responses, experience of case studies on char development, community, and local/national leadership—including National Char Alliance (NCA), and international cooperation and assistance for management of floodplains and the delta.

A New Law for Charland Use and Administration

A new charland legislation would be the foundation for establishing the rights of the displaced and ensureing the distribution of khas land to genuinely poor char dwellers. Any amendments or tweaking of the existing Act of XV (1994) should be avoided. Such amendments from the 1825 A/D Regulation to the Tenancy Act (1950), and more particularly since 1975 (Ordinance LXI of 1975) have only strengthened the hands of the land grabbers, making the displaced and the poor further marginalized.

The government should seriously consider establishing a multidisciplinary working group or task force to review and recommend a new legal framework highlighting the goals of the new legislation, including administration, governance, and monitoring. The scope of work for the task force should include review of the current practices for survey, records, and mapping of new chars in favor of more frequent and timely surveys in a transparent manner conducted by joint teams consisting of survey officials, members of local administration, and civil society.

A Dedicated Agency for Char Development Administration

The 2015 Char Convention demanded the establishment of a National Char Foundation to (a) strengthen the development of char communities and (b) formulate a Char Development Policy. These would constitute the most critical steps in the right direction concerning the future of char development in Bangladesh. However, a Foundation or a Char Development Authority (CDA) and a Char Development Policy (CDP) are only the means toward the goal of better char administration.

The CDA should be in charge of char development in every respect—for surveys, mapping, registration, and recognition of rights/titling, and *all* development functions in coordination with other departments, agencies, and development partners. Ideally, it should be housed under the ministry of land with an independent board of directors coming from various related ministries/agencies (e.g., Disaster Management Bureau/Ministry of Relief and Rehabilitation, Ministry of Law, Ministry of Water Resources/Bangladesh Water Development Board, Local Government Engineering Department, Ministry of Public Health, Ministry of Social Welfare, Planning Commission/Ministry of Finance, etc.), dedicated budget, staffing and led by a secretary-level officer. The CDA should have offices in all five char regions of the country—i.e., (i) Teesta-Brahmaputra-Jamuna; (i) Ganges; (iii) Jamuna-Ganges; (iv) Lower Meghna; (v) Meghna estuarine area to deal with local-level planning and development of the char regions.

Need for Bottom-Up Governance

Char administration and governance are more than laws and policies; how these policies and laws are implemented, including how decisions are taken and enforced. In Bangladesh, typically a top-down approach predominates, with limited or no inputs from beneficiaries and/or civil society members. Decisions are made by top management—in this context, by the Director-General, Land Records and Survey (in Dhaka), or Deputy Commissioner of the concerned district for char land surveys, or by technical experts/engineers for erosion control and bank protection works by the Bangladesh Water Development Board (BWDB) without any major input from local people.

This old way of governance must be replaced by a more open, transparent, and inclusive decision-making process for improving char administration and governance. This will require a decentralized bottom-up approach involving char inhabitants, NGOs, community leaders, and elected local officials from char areas. Such decentralization would be critical to enable engagement with stakeholders, coordination with district administration in the area , and delivery of CDA programs. Further, any strategic ecological and adaptive management plan would require local stakeholders' engagement and participation to make things happen. This is why a bottom-up governance is required to replace the current dysfunctional char administration.

Integrated and Holistic Char Development Policy

A Char Development Policy must be on the agenda to address development needs in an integrated and holistic manner involving both protective/local infrastructure works and comprehensive social and community development programs. The lessons from CLP, CDSP, and other such initiatives may be instructive. The delegates attending the *1st National Char Convention 2015* demanded a broad range of programs from basic primary education to right-based health care, safe access to water and sanitation facilities, and infrastructures like link roads, culverts, solar energy, disaster management, land rights, agricultural development, access to social safety net programs, employment, good governance, citizen rights, and gender equality. Any future CDP must consider these for integrated char development, reinforced by the CLP and CDSP results and outcomes. Attempts at picking and choosing certain char development issues and mainstreaming with national planning may not be as helpful as having dedicated policies and new institutions for integrated char development in the country.

Community, Local/National Leadership

Any fundamental changes in the chars would require leadership at the community and local/national levels and a sense of purpose—i.e., equity, justice, and ethics—among policy makers and program administrators. Various initiatives taken up by a number of national and international NGOs have already contributed to the development of community organizations and capacity-building at local level in many char areas. Leadership at local level can be further enhanced through a concerted effort from concerned government officials, NGO workers and development partners. The *1st National Char Convention 2015* with its slogan "Let the Light of Development spread over the Chars" was such an example, bringing all stakeholders—for example, representatives from char areas, researchers, development actors/activists—and many local, national, and international organizations—for the event to establish an agenda for future char development in the country.

Nearly, 600 of the 1200 participants of the convention were from char areas, and a significant number of them were women from chars. The Speaker of the *Jatiya Sangsad* (National Parliament) was the Chief Guest at the event, which was also attended by members of the *Jatiya Sangsad*, ministers, government officials of different ministries and departments (e.g., agriculture, education, health, ICT, fisheries, livestock, local government, and cooperative), diplomats, and representatives of numerous international development partners having programs in char areas. Dr. Shirin Sharmin Chaudhury, MP and Speaker of the Bangladesh Parliament, in her opening speech remarked that "Char dwellers are citizens of our country as well" and expressed solidarity with the initiative (Krishibid Institution 2015:16). The 14-Point Declaration was later submitted by NCA to the government of Bangladesh with the intent of activating the government in adopting special plans for char development.

NGO Advocacy for Char People and Development

As illustrated by the case studies, the root causes of poverty and vulnerability in char areas cannot be addressed by new laws or policies alone. In the char context, advocacy should be viewed as an integral part of any development program. This is already evident from CLP and CDSP programs. NGO advocacy and their rights-based approach helped program implementation and delivery by creating an institutional environment at various levels—local, sub-district/district, and national—and by working as catalysts for change. Therefore, advocacy by NGOs and civil society organizations should be taken into account in future char development programs.

International Collaborations with Development Partners

Future planning for the char areas will require research and development cooperation with bilateral and multilateral agencies and their continued support in various projects and programs related to char and estuary development. There is much to be learned from past collaborations. It is also necessary to keep up-to-date with the physical and natural processes of river systems and chars for any long-term solution. An interdisciplinary dialog on human-environment relationship would be critical, particularly in view of the impending climate impact scenario, in designing any sustainable development program for the riverine and coastal chars of the country. This should be considered with due importance in dealing with all aspects of char development. Further, the interdisciplinary dialog should critically look into ways of reducing population pressure in chars in the longer run, particularly in those coastal chars that are too hazardous for human habitation from the point of view of natural disasters.

Rethinking Solutions

The chars in the floodplains and the delta in Bangladesh connote a unique environment. One has to bear in mind the significant differences in the ecology, economy, demography, and local institutions between the mainland and the chars. The charlands in general are more susceptible to changing courses of the river, where dispute over land is nearly a rule. People who live on charland may not have control over its use. Besides, most chars are remote from the nearest seat of local upazila administration, thereby making it difficult to enforce the administrative laws and rules in there.

The unique ecological context and significant variations between the main land and the char, and the lessons from past development experience in the charlands demand unique solutions for the riverine and coastal chars. This is further evident from the 14-Point Declaration of the 1st Char Convention 2015 and the demand for a special plan for char development. In essence, char development requires new legal framework establishing rights of the char people over land, and a decentralized development plan with a bottom-up structure of governance. The char people have spoken and the onus now is on those who are in authority to make the necessary difference.

Glossary

Abadkari Reclaiming cultivator
Adarsha Gram Model village (for landless families)
Aman Local variety of rice
Ameen Land surveyor
Ashar Bengali month (mid-June)
Ashrayan Prokolpa Housing project (for the poor and landless)
Aus A rice variety (season—between summer and winter)
Bagda Saline water prawn
Bali Sandy soils
Bangla Bengali language
Bathan Temporary shelter in new chars
Bazaar/s Rural market/s
Bhadraloks Gentlemen (literate, well-mannered folks of high status)
Bigha Unit of measurement for land (33 dec)
Bepari/s Medium trader/s
Bkash Money transfer through cell phone by using apps
Bonna High, abnormal flood/disastrous
Borga Shared system
Boro A rice variety
Borsha Monsoon rain/normal flood
Boro Local variety of rice
Chapories Cluster of islands/chars in Assam
Char/s Sandbars/shoals/islands in between channels
Chatal Large levelled and predominantly cemented floor area used for drying crop
Chewa A fish variety
Choura Literally char resident; however, mainlanders use it as a slur to undermine char residents
Choruas Char resident; same as *choura*
Dadon An informal system of credit
Deshi Local variety

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Diara Another word for chars
Forias Small traders/middlemen
Ghaa Symptoms are painful sores on the feet, caused by standing in water for long period
Gher Prawn farming
Goalas Local milk purchasers
Goalbathan Temporary animal shelter in chars during winter season
Golaghor Community barn
Golda Sweet water prawn
Guchhagram Cluster village (built for landless and poor families)
Haat Weekly rural market
Hilsa National fish
Jatiya Sangsad Parliament
Jotedar Landowner
Jupri/s Shacks/houses made of fragile materials such as bamboo and straws
Kaon Millet
Khal Canal
Kharif Agricultural season (May to October)
Kharif-I (Mid-March to Mid-July)
Kharif-II (Mid-July to Mid-November)
Khas land Government land available for lease etc.
Khatian Land title
Killa A raised mound on which animals can be gathered
Kussum Sunflower
Kutcha Houses made of mud or cheaper materials
Lapta payasti Accretion to existing land
Lathiyali A system of patronage relation between landlords and peasants in Bengal
Lathiyals Clubmen (of wealthy landowners)
Lungi Traditional dress for men
Macha Raised platforms to avoid flooding
Madrasa School for Quranic learning
Mohajons Large traders (also, informal money lenders)
Mahisyas Bengali Hindu cultivating or agrarian caste
Maliks Tenants (often refer to head of household in some districts in Bangladesh)
Monga Seasonal hunger (or near starvation) caused by food insecurity in north-western districts
Mouza Land revenue/administration unit/cadastral map
Namasudra Bengali Hindu cultivating caste/boatmen
Nuton Jibon New Life (Formerly Social Improvement Programme Project)
Payasti Addition to the existing land
Piker Wholesalers
Pods Fishing caste, typically concentrated in Sundarbans area
Pucca House made of brick/cement
Purdah Veil
Rabi Agricultural season (November–April)

Raiyats Persons who acquired a right to hold land for the purpose of cultivating it
Salish Local dispute resolution session
Samaj Social groups based on kinship or other basis such as religious sects
Sari/s Traditional dress/es for Bengali women
Shouhardo Strengthening Household Ability to Respond to Development Opportunity
Sidr A deadly cyclone
Sikosti Reformation of land in situ or original site
Sutika/shutika Post-partum diarrhea and anemia considered to be life-threatening
Talukdar Land owning ruling class during the Mughals/British rule for tax collection
Tehsildar Land Revenue Officer
Til Sesamum
Tush Rice husk
Union Parishad Union Council (the lowest tier in local government administration)
Upazila/s Subdistrict/s
Upazila Parishad Sub-District Council (intermediate tier in local government administration)
Uthuli Household relocated with permission on properties owned by relatives/non-relatives
Zamindars Landlords, who lease out land to tenants (introduced under the Permanent Settlement Act of 1793 by the British raj)
Zila Parishad District Council (apex tier in local government administration in Bangladesh)

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