Koen de Wilde studied political and social science at the University of Amsterdam. He has a vast working experience in Bangladesh, in various capacities, spanning a period of more than thirty years. He was involved in the different stages of the Char Development and Settlement Project (CDSP) along the southeastern coast, and in Integrated Coastal Zone Management.

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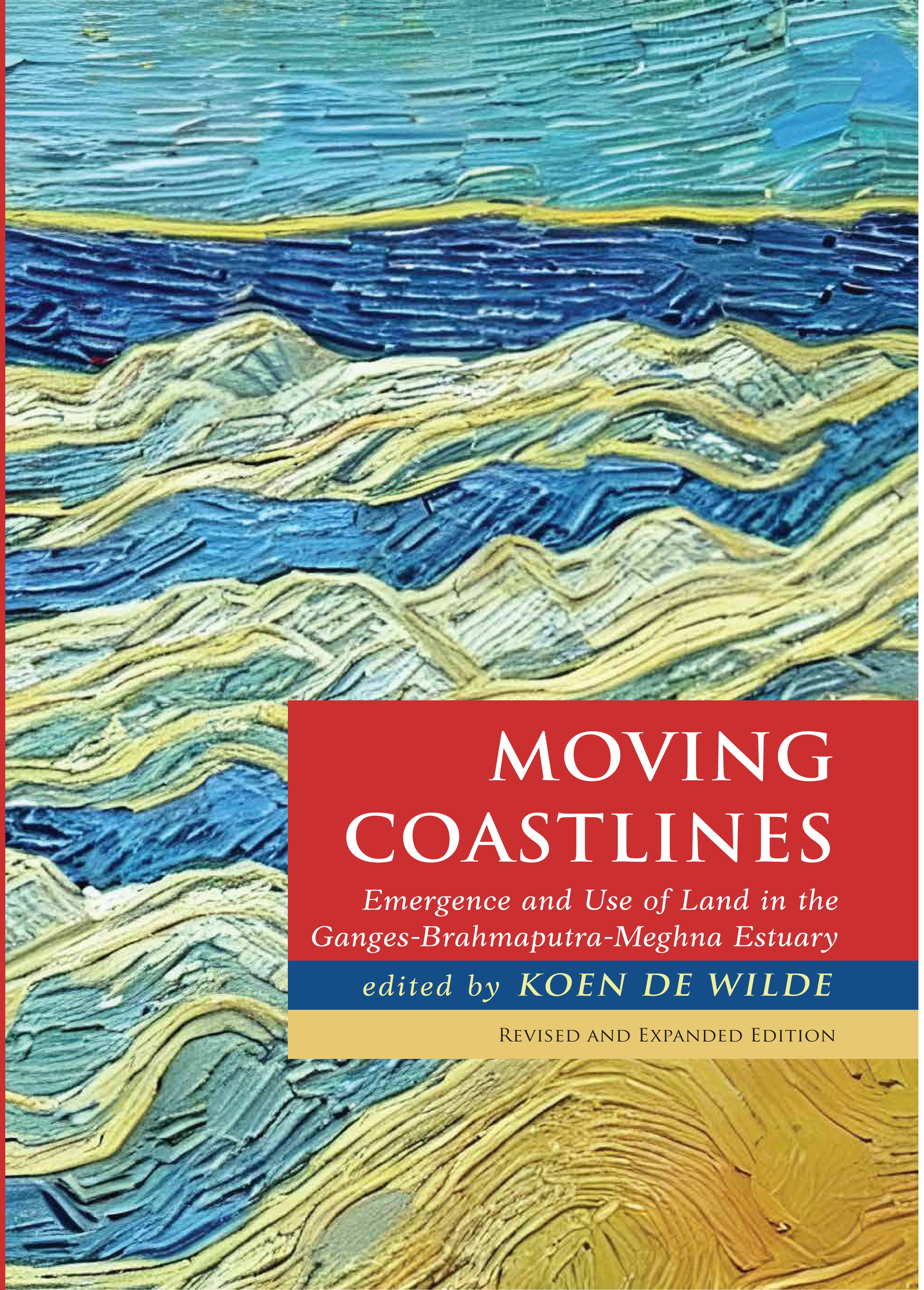

MOVING COASTLINES

Emergence and Use of Land in the Ganges-Brahmaputra-Meghna Estuary

edited by ***KOEN DE WILDE***

Revised and Expanded Edition

The Ganges-Brahmaputra-Meghna estuary forms the central and most dynamic part of the coastal zone of Bangladesh. It is being shaped by a complex pattern of interactions between phenomena as the discharge of water, the sediment load, tidal forces, and estuarine circulation. This leads to a permanent process of formation and erosion of land and, indeed, to moving coastlines. It is a unique environment, not seen at this scale in any other part of the world.

The book follows three interwoven themes. It follows a chronological line, focusing on natural and biological resources: the emergence of land and the subsequent use of new land for forestry, fisheries, animal husbandry, agriculture and infrastructure. It highlights the people and their institutions. Erosion victims lose their land and move to new *chars*, building new livelihoods in a harsh environment. Community-based institutions emerge and government gradually makes its influence felt in these virgin territories. The third theme is the impact of climate change on the livelihoods of people and on the physical processes in the estuary. Special attention is given to the Bangladesh Delta Plan 2100.

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Moving Coastlines

MOVING COASTLINES

Emergence and Use of Land in the Ganges-Brahmaputra-Meghna Estuary

edited by ***KOEN DE WILDE***

REVISED AND EXPANDED EDITION

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List of Abbreviations and Acronyms

AC	Assistant Commissioner
ADB	Asian Development Bank
ADP	Annual Development Program
ADM	Adaptive Delta Management
AEZ	Agro Ecological Zone
AIGA	Alternative Income Generating Activity
AOS	Annual Outcome Surveys
AR	Assessment Report
ASPS	Agricultural Sector Program Support
BAP	Bismillah Agro Production
BCCSAP	Bangladesh Climate Change Strategy and Action Plan
BCCT	Bangladesh Climate Change Trust
BDP	Bangladesh Delta Plan
BFRI	Bangladesh Forest Research Institute
BIWTA	Bangladesh Inland Water Transport Authority
BMD	Bangladesh Meteorological Department
BNRS	Bangladesh National REDD Strategy
BRAC	Bangladesh Rural Advancement Committee
BRRI	Bangladesh Rice Research Institute
BT	Bhatir Tek
BUET	Bangladesh University of Engineering and Technology
BWDB	Bangladesh Water Development Board
CAARP	Community Agriculture and Aquaculture Resource Person
CBA	Community-based Adaptation
CBD	Char Baggar Dona
CBO	Community-based Organization
CBT	Char Bhatir Tek
CDS	Coastal Development Strategy
CDSP	Char Development and Settlement Project
CEGIS	Center for Environmental and Geographic Information Services
CEIP	Coastal Embankment Improvement Project
CHT	Chittagong Hill Tracts

CIMMYT	International Maize and Wheat Improvement Center
CL	Char Lakhi
CLAP	Coastal Livelihoods Adaptation Project
CLW	Community Livestock Worker
CM	Char Majid
CMIP	Coupled Model Intercomparison Project
CO	Char Osman
CO2	Carbon di-oxide
CPP	Cyclone Preparedness Program
CS	Cadastral Survey
CSICRD	Climate Smart Integrated Coastal Resource Database
CV	Clustered Village
CZ	Coastal Zone
DAE	Department of Agricultural Extension
DANIDA	Danish International Development Agency
DFID	Department for International Development
DGC	Delta Governance Council
DGLRS	Directorate General of Land Records and Surveys
DLMS	Digital Land Management System
DOD	Day Old Ducklings
DOE	Department of Environment
DOF	Department of Fisheries
DPHE	Department of Public Health Engineering
dS/m	Deci-siemens per meter
DSR	Direct seeded rice
EbA	Ecosystem-based Adaptation
EC	Executive Committee
ECA	Ecological Critical Areas
EC_e	Electrical Conductivity equivalent
ECNWRC	Executive Committee National Water Resources Council
EDP	Estuary Development Program
EEZ	Exclusive Economic Zone
EH	Eastern Hills
EIA	Environmental Impact Assessment
e.g.	exempli gratia — for example
ESCAP	Economic and Social Commission for Asia and the Pacific

EWS	Early Warning System
FAO	Food and Agriculture Organization of the United Nations
FCD	Flood Control Drainage
FCD(I)	Flood Control Drainage (Irrigation)
FD	Forest Department
FF	Farmers Forum
FFS	Farmer Field School
FR	Flood Risk strategy
FW	Freshwater strategy
FY	Financial Year
GBM	Ganges-Brahmaputra-Meghna
GCF	Green Climate Fund
GDP	Gross Domestic Product
GED	General Economics Division
GIFT	Genetically Improved Farmed Tilapia
GIS	Geographical Information System
GMSL	Global Mean Sea Level
GNAEP	Greater Noakhali Aquaculture Extension Project
GoB	Government of Bangladesh
GPFO	Guidelines for Participatory Farmer Organization
GPS	Global Positioning System
GPWM	Guidelines for Participatory Water Management
GT	Gangchil Torabali
GTZ	German Technical Cooperation Agency
HH	Households
HYV	High Yielding Variety
ICCCAD	International Center for Climate Change and Development
ICS	Improved Cooking Stoves
ICZM	Integrated Coastal Zone Management
IDA	International Development Association
i.e.	id est — that is to say
IEC	Information Education Communication
IFAD	International Fund for Agricultural Development
IFI	International Financial Institution
IIED	International Institute for Environment and Development
IMSC	Inter-Ministerial Steering Committee

IP	Internet Protocol
IPCC	Intergovernmental Panel on Climate Change
IPF	Integrated Prawn Farming
IPSWAM	Integrated Planning for Sustainable Water Management
IRRI	International Rice Research Institute
ITTO	International Tropical Timber Organization
IUB	Independent University Bangladesh
IUCN	International Union for Conservation of Nature
IWM	Institute of Water Modelling
IWT	Inland Water Transport
JRC	Joint River Commission
LADC	Local Area Development Committee
LCS	Local Contracting Society
LF	Local Facilitators
LGED	Local Government Engineering Department
LGI	Local Government Institution
LRMS	Land Records Management System
LRP	Land Reclamation Project
MAA	Muhuri Accreted Area
MAEP	Mymensingh Aquaculture Extension Project
MD	Mora Dona
M&E	Monitoring and Evaluation
MES	Meghna Estuary Study
MHW	Mean High Water
MIDPCR	Market Infrastructure Development Project in Charland Regions
MoU	Memorandum of Understanding
MOWR	Ministry of Water Resources
MP	Member of Parliament
MSL	Mean Sea Level
NABA	Noakhali Agribusiness Association
NAEP	New Agriculture Extension Policy
NAPA	National Adaptation Program of Action
NARS	National Agricultural Research System
NbS	Nature-based Solutions
NC	North-Central
NCAP	Netherlands Climate Change Assistance Program

NDA	National Designated Authority (Green Climate Fund)
NE	North-East
NGO	Non-Governmental Organization
NW	North-West
NWO	Nederlandse Organisatie voor Wetenschappelijk Onderzoek — Dutch Organization for Scientific Research
NWP	National Water Policy
NWRC	National Water Resources Council
O&M	Operation and Maintenance
PBAEP	Patuakhali Barguna Aquaculture Extension Project
PBSA	Participatory Benefit Sharing Agreement
PC	Polder Committee
PCD	Project Coordinating Director
PDZ	Productivity Zone
PL	Post-Larvae
PMC	Project Management Committee
PMG	Producer and Marketing Group
PPCR	Pilot Program in Climate Resilience
PPP	Public-Private Partnership
PPSC	Delta Plan Project/Program Selection Committee
PRA	Participatory Rapid Appraisal
PRSP	Poverty Reduction Strategy Plan
PSF	Pond Sand Filter
PTPS	Plot-to-Plot Survey
PVA	Participatory Vulnerability Assessment
PVA	Participatory Vulnerability Assessment
PW	Poultry Worker
PWD	Public Works Department
RCOFTC	Regional Community Forestry Training Center
RCP	Representative Concentration Pathways
REDD	Reducing Emissions from Deforestation and Forest Degradation
RFLDC	Regional Fisheries and Livestock Development Component
RHH	Rice-Husk duckling Hatchery
RS	Revision Survey
RWA	Rapid Water-management Appraisal
SA	State Acquisition
SAIP	Southern Agriculture Improvement Project

SARCCAB	Support to Agricultural Research for Climate Change Adaptation in Bangladesh
SDG	Sustainable Development Goals
SEZ	Special Economic Zone
SDI	Self Development Institute
SFG	Social Forestry Group
SH	South Hatiya
SHS	Solar Home System
SIA	Social Impact Assessment
SIBDP	Support to Implementation of BDP2100
SLDP	Smallholder Livestock Development Project
SLR	Sea Level Rise
SNCA	South Noakhali CBO Association
SOB	Survey of Bangladesh
SPC	Sub Polder Committee
SRDI	Soil Resource Development Institute
SRT	Sex-reversal Tilapia
SUN	Sandwip-Urir Char-Noakhali
TA	Technical Assistance
TPR	Transplanted rice
TRM	Tidal River Management
TUG	Tubewell Users Group
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNESCO	United Nations, Educational, Scientific and Cultural Organization
UNICEF	United Nations Children's Fund
UNO	Upazila Nirbahi Officer
UNU	United Nations University
UP	Union Parishad
WARPO	Water Resources Planning Organization
WASA	Water Supply and Sewerage Authority
WFC	World Fish Center
WMA	Water Management Association
WMF	Water Management Federation
WMG	Water Management Group
WMO	Water Management Organization

Glossary

Ails	Rice field bunds
Aman	Rice crop grown in monsoon, July-November
Aus	Crops grown in March-June period
Bahini	Armed gang
Baor	*Beel* (see below)
Batainna	Person taking care of large herds
Bathan	Large herds in open grazing land
Beels	Inundated low-lying land with static fresh-water
Bigha	One third of an acre of land
Borga	System with shared revenues between cattle owner and care takers
Boro	Irrigated winter crop
Burkha	Veil used by Muslim women to maintain purdah
Charcha	Draft survey map prepared for immediate settlement
Dadun	Money lender, depot holder
Dakter	Traditional, unqualified healer
Deshi	Local
Diara	Type of land survey
Ghats	Landing facility for boats
Gher	System of rice-fish-fresh water prawn culture
Gorur hat	Livestock market
Hali	Quantity of four eggs
Haor	Saucer-shaped natural depression with fresh-water marshes
Jamabandi	Document containing description of the land to be settled to a household
Jatka	Hilsa juvenile
Jodhs	Record of Rights with name of legal ownership for a specific land plot
Jotdar	Powerful person, usually big landowner
Kabuliyat	Deed of agreement
Khal	Canal, stream
Kharif I	*Aus* season crop grown in March-June period
Kharif II	Monsoon season crop, grown in July-November period
Khas	State owned land
Khatian	Record of right on land

Khudra dol	Small sub-group
Killa	Raised earthen mounds
Madrassa	Traditional religious school for Muslim children
Maji	Boat owner
Mouza	Basic unit used in revenue map
Palli samaj	Village society
Parishad	Council
Patil wala	Local trader
Pourashava	Municipality
Purdah	Muslim practice of female seclusion and isolation from men outside their immediate family
Rabi	Winter crops, grown in December-March/April period
Salami	Token price
Samaj	A small group of households that identify themselves as a separate social unit
Shalish	Local judicious meeting
Shona bang	Bull frog
Sorjan	System of rice cum fish culture
Upazila	Sub-district

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Foreword to Second Edition

I am so pleased to learn that the "Moving Coastlines — Emergence and Use of Land in the Ganges-Brahmaputra-Meghna Estuary" has gone to its second edition.

It vindicates that a decade following the first edition, the issues and subjects presented in the book hold currency and importance across a widespread readership in Bangladesh and beyond.

The (current) updated and expanded version comes out as we celebrate 50 years of diplomatic ties between Bangladesh and The Netherlands. It has been a period of mutual learning and beneficial cooperation between the two peoples in the two densely populated deltas. As Bangladesh Embassy celebrated Bangladesh-Netherlands friendship in Grote Kerk in The Hague (28 March 2022), I underlined how the works of individuals like Koen de Wilde quietly contribute to a remarkable tie shaping between the two deltaic people notwithstanding the long distance in physical measure.

Over the past decades, coastal development has been a key component of our engagement. Projects and programs, e.g., Land Reclamation Project, Meghna Estuary Survey, Estuary Development Program, Integrated Coastal Zone Management Project and the ongoing Char Development and Settlement Project show the breadth and length of collaboration in the development of our ecology and livelihoods along our vast coastline.

This is also a time when the Government of Bangladesh is advancing with firm commitment to implement Bangladesh Delta Plan 2100. Clearly the BDP stands out as a signature of Bangladesh-Netherlands cooperation bringing to the table Dutch expertise and experience from an array of Dutch individuals and knowledge institutions. Coastal development features prominently in the Plan.

The book is also a notable instance of 'working together' between the Bangladesh and Dutch (and other nationalities) professionals. Being in The Netherlands, I heard unique accounts of how the Dutch experts appreciated and unpacked the complexities in the (greater) Noakhali district area which remains a most dynamic part of Ganges-Brahmaputra-Meghna delta. This is where land accretion and erosion significantly impact the livelihoods of millions of coastal settlers. The contributors to the book, coming with diverse backgrounds, joined in producing a multi-disciplinary and rich publication under three themes running throughout the entire book, i.e., formation and use of new land, people and institutions, and climate change.

At a personal level, hailing from the Noakhali region, the accounts and challenges make me fathom the complexities more. I had seen first-hand the social and economic challenges that came in the wake of the physical dimensions shaping the delta, the harshness of the environment that coastal settlers cope with and also so much resilience the people demonstrate. Much of the layers of complexities so often is felt a little deeper inland the delta.

Sincerely,

The Hague, April 2022

M Riaz Hamidullah
Ambassador of Bangladesh
in The Netherlands

Foreword to First Edition

It is with great honour that I write the preamble to this book as now, more than ever, there is a need for strategies that work to manage and develop coastal resources. The book before you is not only a description of the development of the Bangladesh coastal zone, but also a tribute to the men and women that over the years spent their career in service of people living in the coastal zone. But foremost it is a tribute to the people in the coastal zone itself that are faced with the challenge of surviving in a dynamic and unforgiving environment.

The Bangladesh coastal zone is a harsh place to live. In order to support the development of coastal communities, experts from different countries worked together with the Bangladesh Government to develop an integrated coastal zone development model suitable for the coastal zone of Bangladesh. This model was piloted and further developed under the Char Development and Settlement Projects. The model is based on the theorem that in order to develop, people need both social and physical security as well as secure ownership. The success of this model can literally be seen in the areas that have been developed under CDSP-I, II and III. Chars that had poor soils before the start of the project are now bustling with activities, unlocking the human and economic potential of the chars. These areas now contribute not only to the welfare of the people living there but also to the local and national economy as a whole. This approach has attracted international attention, prompting the International Fund for Agricultural Development to join the partnership and invest in CDSP together with the Bangladesh Government.

Through different projects (such as the Char Development and Settlement Projects and the Estuary Development Projects), the Government of Bangladesh now has the policy tools in hand to plan and implement its development in a programmatic and integrated manner. In order to address the challenges of the future, the Netherlands will continue to support Bangladesh through its 'Water Mondiaal Programme' to further strengthen coherent policy planning and implementation.

People in the coastal zone are used to changes and have been able to adapt to a dynamic changing environment for centuries. Climate change poses an additional challenge as changes are most likely to be substantial and will happen over a relatively short period. The exact implications of climate change for Bangladesh are still unclear. Despite these uncertainties, policies must be developed and implemented, now based on a delta wide approach, in order to be prepared for the likely changes in the future.

In this book, the authors build on their own experience in the coastal zone as well as on the vast body of knowledge created over the years on coastal zone management. Their work will be an important contribution to the ongoing debate on how to address the challenges of the future.

Sincerely,

Dhaka, December 2010

Alphons Hennekens
Ambassador of
the Kingdom of the Netherlands
in Bangladesh

Preface to Second Edition

I am greatly indebted to the authors who enthusiastically accepted the invitation of the University Press Ltd. To prepare a second edition of "Moving Coastlines". The book was first published early 2011 and the publisher observed a continued interest in the subject from professionals working with coastal issues, from students and from the general public. This prompted the idea to bring a second, revised and updated version on the market.

Many authors moved to different positions over the past decade (one quipped that he moved more than the coastline), sometimes out of the sphere of coastal development, and to different phases in their lives. This makes it even more laudable that they worked on the present edition in their own free time, as was the case ten years ago. The team of authors is for the most part the same. Hasan Zubair, who wrote on matters of Operation and Maintenance, sadly deceased in 2019. Ahana Adrika (contributed to climate change adaptation) did not contribute this time because she could not be contacted after emigration. Four new authors joined: Jaap de Heer prepared the two Chapters (12 and 13) on the Bangladesh Delta Plan 2100, Chapter 13 together with Giasuddin Choudhury and William Oliemans; Rezaul Karim assisted in updating Chapter 8 on land settlement.

Chapter wise, the book has a similar structure as the 2011 publication, with two additional chapters on the Bangladesh Delta Plan 2100. The current edition has new elements due to developments that occurred since 2010. To mention a few: progressive insights into the extent and consequences of climate change, new policies and plans from the side of the Government of Bangladesh, additional primary data collected from projects in the central part of the coastal zone and new publications on the many aspects of coastal development. It follows the same three themes as ten years ago: the formation of new land and its subsequent use, people and institutions and the impact of climate change.

Utrecht, August 2020. Koen de Wilde

Preface to First Edition

Exactly a decade ago, in 2000, the University Press Ltd. Published "Out of the periphery — Development of Coastal Chars in Southeastern Bangladesh". The book gave an account of the experiences of the first and of a part of the second phase of the Char Development and Settlement Project (CDSP). The project at the time was operational in char areas of the Districts of Lakshmipur, Noakhali, Feni and Chittagong. The book sought to be a sort of a manual for future development efforts in the chars, not so much by prescribing a number of off the shelf recipes, but by discussing issues and reporting on responses that were developed in CDSP.

People, related to CDSP and to other development projects in the char areas of the central region of the Bangladeshi coast, thought it opportune to work on a new book, ten years on. The additional years of experience were worthwhile to reflect on and to make them accessible to a broader public. In that period, ever more evidence came to light that the climate was undergoing a change on a worldwide scale. Concepts like climate change, global warming and sea level rise are now practically household words, while they were virtually not heard of in discussions on development ten years ago. To write about the low lying coastal zone of Bangladesh is not possible without discussing the already felt, the probable and the possible consequences of climate change.

At the same time it was felt that a new book should transcend the story of one particular project. The activities of CDSP, though covering many sectors, are still limited and do not address all aspects of life of people living in the exposed coastal zone. The project deals with the use of new land, not with the process of land formation. To broaden the "CDSP only" scope of "Out of the periphery", authors of the Forest Department, the Bangladesh Water Development Board, IUCN Bangladesh, the Institute of Water Modeling, the Center for Environmental and Geographical Information Services, the Regional Fisheries and Livestock Development Component (RFLDC) and the Estuary Development Programme, joined staff — and ex-staff members of CDSP in the production of the current book.

The main aim of "Moving coastlines" is to inform an interested readership about, as the sub-title promises, the formation of an essential natural resource, land, and about what is done with the land, once it is there. The emergence of land at the scale it is occurring in the Ganges-Brahmaputra-Meghna estuary is a rather unique phenomenon. And so is the pressure of the population, often erosion victims, to build up a decent livelihood on these new lands. These are ingredients for a fascinating scenario and the authors only hope that some of it is captured in the pages of this book.

A second aim, of another level, was to make information available to a broader public, that had otherwise not traveled beyond the bookshelves and cupboards of a few offices in Dhaka. Much valuable and, so to speak, home grown data, are locked up in all sorts of project publications, that usually have a very limited readership. As you can see in the list of references at the end of every chapter in the book, these project related publications have been intensely used while drafting the book's contents.

The book has no aspirations to be scientific. First and foremost, it wants to tell the story of the people and the natural resources they are so dependent on, in the delta of Bangladesh. Many of the contributors to the book do not have a scientific background, and all of them are rather field people, more than desk people, if this is a fair distinction. The book abstains from footnotes, in order not to disrupt the flow of the text. All publications that were used can be found in the list of references, and readers are welcome to contact any of the authors by e-mail (addresses are on the next pages).

I want to finish with thanking all of my colleagues who contributed to this book. They engaged in writing after working hours and in weekends to complete their chapters and to comment on the chapters of others. I also want to thank Pauline, my wife, who, with her teacher's eyes, gave invaluable support in avoiding complicated sentences and making the text easier to access. And, lastly, all of the authors want to express their gratitude to those organizations that made the publication possible by guaranteeing to purchase the book: the Embassy of the Kingdom of the Netherlands (through CDSP), RFLDC, Euroconsult Mott MacDonald, Royal Haskoning and BETS Consulting Services.

Dhaka, December 2010. Koen de Wilde

Chapter 1

Setting the Stage

Dr. Sultan Ahmed and Koen de Wilde

1.1 THE COASTAL ZONE

1.1.1 Defining the Coastal Zone

The coast is not a fixed, static line between land and sea, but rather an area where interaction between land and sea takes place. This interaction takes many forms and timeframes, ranging for instance from daily tidal movements to long term land formation processes. The title of this book hints at the fact that the Brahmaputra-Ganges-Meghna rivers system constantly carries sediment to the estuary in the Bay of Bengal, originating from distant places in its catchment area in northern-India and the Tibetan Plateau. It could be argued that the whole catchment should therefore be considered as part of the coast. It exposes the dilemmas faced by policy makers in defining the coastal zone.

In Bangladesh, the Coastal Development Strategy (CDS) of 2006 (see section 1.2.2 below) has taken a pragmatic approach, applying a hybrid definition with physical and administrative criteria. Three physical phenomena, characteristic for the coastal areas, have been taken into account: tidal movements, salinity intrusion and risk of cyclones and storm surges. Tidal functions are for a large part the driving force behind processes as erosion and accretion, salinity intrusion, drainage problems and flooding. Differences between high and low water levels during the day have been taken as the discriminating factor: an average value of 0.3 meter was taken as threshold. Areas with higher fluctuations were considered to belong to the coastal zone. Fluctuations in water level and water flows from upstream areas to the coast determine for a great deal the extent of salinity intrusion. Three different indicators were used for soil (4 dS/m), surface water (5dS/m) and groundwater (2 dS/m) salinity levels. Areas with higher values were seen as coastal. A cyclone risk map (prepared by the Department of Disaster Management) distinguishes four risk zones: no risk; wind risk; risk; and high-risk. Both the risk and the high-risk zones have been incorporated in the coastal zone. In addition to the land area, the Exclusive Economic Zone (EEZ), as defined by the

United Nations, is considered to be a part of the coastal zone. The interests of all resources in this zone are vested in Bangladesh.

After the national level, Bangladesh has Divisions (eight in total) as the next administrative level, with an emphasis on coordination more than on executive power. The Districts (64) form the key layer of administration as far as law and order and implementation of activities is concerned. Each District is divided into Upazilas (sub-districts), headed by an elected Upazila council. Bangladesh has 492 Upazilas (as of July 2020). Applying aforementioned criteria, the CDS identifies 147 Upazilas as being coastal. Subsequently, a District is taken as coastal when it includes one coastal Upazila. These Upazilas are located in 19 Districts, delineating the coastal zone.

The Bangladesh Delta Plan 2100 (BDP2100) of 2018 takes as a starting point an expansive definition of the Bangladesh delta region: all districts that face various natural hazards owing to the deltaic formation of the country and the related interface with the vast river networks, the Bay of Bengal and climate change. For purposes of water resource planning the plan has divided Bangladesh into eight hydrological regions: Northwest, Northeast, North-central, Southeast, South-central, Southwest, Eastern Hills and the main Rivers and Estuaries. Subsequently the plan focuses on the natural hazard vulnerabilities facing each of these regions. This has led to a grouping of areas with the same kind and magnitude of risks of natural hazards, in other words where similar hydrological and climate change vulnerability characteristics and problems converge. The plan comes to six of such groupings (coined "hotspots"): the Barind and drought prone areas; the Chittagong Hill Tracts; the Coastal Zone; the *Haor* and flash flood areas; the river systems and estuaries; and the urban areas.

The coastal zone in BDP2100 consists of the same 19 Districts as in the CDS. According to BDP2100 the coastal zone had a population of 22.4 million in 2011, with an average population density of 807 per square km. Currently, even in sea facing polders in south Noakhali, a density of 1,000 is not uncommon.

Coastal resources are under pressure worldwide. It is estimated that about 40% of the world's population lives within a band of 100 km off the coastline. Nearly 15% lives in the low elevation coastal zone, land with maximum10 meters elevation contiguous with the coast, which occupies 2% of the world's land mass. Current trends show a migration towards coastal areas, further intensifying the competition for access to coastal resources.

1.1.2 Regional Differentiation

As is done in the Government's Concept Note on Integrated Coastal Zone Management of 1999 (see section 1.2.1), the 710 km kilometers long coast can be divided into three distinct regions: east, central and west. This division is made based on the geo-morphological conditions and hydrological features. Factors that are taken into account are, among others, the network of rivers, the river water — and sediment discharge, the location of islands in between the channels, the position of the Swatch of No Ground and the funnel-shaped shallow northern Bay of Bengal. A recast and modified map (Figure 1.1) shows these regions and the Districts that were defined as coastal districts in the Coastal Development Strategy. BDP2100 identifies four hydrological regions along the Bay of Bengal falling in the coastal zone, dividing the central zone in south-central and southeast.

Morphologically, the eastern coast of Bangladesh from Big Feni River to Badar Mokam (the southern tip of the mainland) is named as the "Pacific type" coast, running parallel to the young mountain ranges of the Chittagong Hill Tracts. This region is regular and unbroken and is protected along the coastline by mud flats and submerged sands. A continuous strip of sand runs from Cox's Bazar to Badar Mokam and forms a 145 kilometers long sea beach. The smaller rivers of the eastern region—Karnaphuli, Sangu, Matamuhuri, and Naf—contribute to the active nature of the region.

The central region runs from the Big Feni River estuary in the east to the Tetulia River in the west. It includes the mouth of the Meghna River, the end of the Ganges-Brahmaputra-Meghna rivers system. An essential feature of this region is the presence of huge quantities of sediment in the water. It is the most dynamic region of the coastal zone and most of the land accretion and erosion occurs here. The coastline in this region is highly broken and consists of a series of islands and chars connected to the mainland, formed by sediment deposits. The relatively shallow funnel-shaped apex of the Bay of Bengal is part of the Meghna Estuary. The rivers falling into the Bay change their course over time (see Chapter 2). Generally, water flows here westward heading towards the Swatch of No Ground. As a result, erosion takes place on the eastern side of the islands and accretion on the western side. Consequently, large islands such as Hatiya, Manpura and Shahbazpur (Bhola) have appeared beading westward. General water circulation is different in the north-eastern part of the Bay. Water in the Hatiya and Sandwip channels flows directly south-east during outgoing tides. As a result, in this area erosion occurs on the north side of the islands, while sediment deposits occur on their southern edge.

The western region is termed as the "Atlantic type" where the coastline is transverse to the continental margin and covers part of the Bangladesh coastline westward from the Tetulia River to the international border with India located at the Harjabhanga River. This is a stable region and is for a part covered with dense mangrove forests. Erosion is confined to the river channels which are deeper than those in the other regions. Accretion hardly occurs in this region and is concentrated at a few points. The sediments in the rivers of this region flow almost directly south to the Swatch of No Ground, which has a considerable influence on tidal characteristics, sediment movement and deposition, and other hydrodynamic and morphological phenomena.

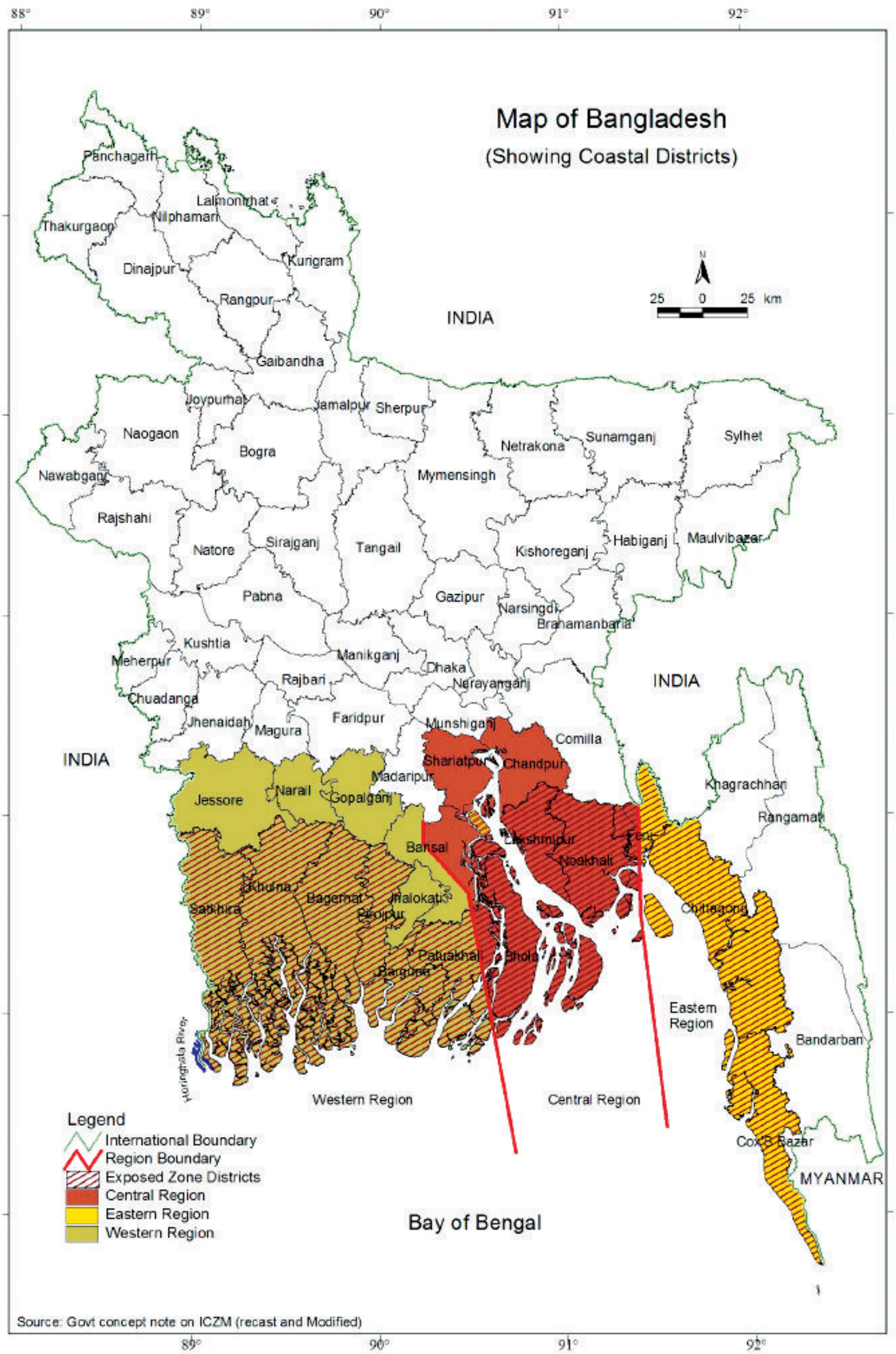

Figure 1.1: The Coastal Zone of Bangladesh and the Three Geo-Morphological Hydrological Regions

This book is about the central region of the coastal zone, as mentioned the most dynamic one. Much of the book focuses on the Greater Noakhali area, composed of the Districts of Lakshmipur, Noakhali and Feni. This is especially true for the chapters on fisheries, livestock and agriculture, as well as the ones on social conditions and the way communities cope with climate change.

1.1.3 Vulnerabilities of Coastal Communities

Coastal communities face multiple vulnerabilities more varied and more intensive than those faced by most of the more inland situated communities. Major threats to people living in the coastal zone are cyclones and storm surges, floods, drainage congestion and water logging, droughts and salinity intrusion, erosion and deteriorating ecosystems. These uncertainties are exacerbated by the inevitable consequences of climate change and climatic variability. Greater probability of cyclones and storm surges, increased rainfall during the monsoon season, less precipitation in winter, higher temperatures and sea level rise will have an adverse impact on livelihoods of people in the coastal zone. Food security will be threatened and conflicts over scarce natural resources are likely to become more prevalent. Coastal livelihoods are endangered. The increased population pressure will make the scenario more precarious. These hazards are not uniformly distributed and show regional patterns. The frequency of every category of hazards is anticipated to increase in the coming decades with climate change. In particular, the exposed part of the coastal zone, directly facing the sea, already facing high risk because of population density and backward socio-economic development, must inevitably encounter elevated risk levels.

People that lose their land because of erosion, face the choice of trying to find employment in their own area as landless laborer or move to newly emerged chars where they can possibly obtain access to land again. Many opt for the latter, causing a nearly constant flow of migration within the coastal area. This accentuates the importance of the development of the exposed coastal zone, including the newly formed chars. Communities in the coastal zone have a legacy of coping with recurring adversity. Their resilience is proverbial. Still, improving the security of coastal communities in socio-economic and physical terms by enhancing their capability to cope with the uncertainties of natural hazards, is an obvious priority for government policies and actions.

1.2 POLICIES PERTAINING TO THE COAST

The policy context of coastal development is firmly given shape by the Coastal Zone Policy and Coastal Development Strategy, but many other policies have a bearing as well. There is a host of sectoral policy and strategy documents (as for instance on forestry, environment, fisheries, agriculture) all with greater or lesser significance for the coastal zone. It would go too far to dwell on all of these declarations. Apart from the Coastal Zone Policy and the Coastal Development Strategy, this paragraph is limited to the National Water Policy and National Water Management Plan, the Bangladesh Climate Change Strategy and Action Plan, the Perspective Plans of Bangladesh, the Bangladesh Water Act and the Bangladesh Delta Plan 2100. But before discussing these policies and plans, attention is given to integrated coastal zone management (generally referred to as ICZM), a concept which essentially forms the basis of much of the thinking on coastal zone development. Elements of ICZM can be observed in all of the aforementioned policies.

1.2.1 Integrated Coastal Zone Management

Looking back on the past sixty years, a shift in focus can be distinguished in the development of coastal development. Till the 1970s, an emphasis was put on the sectoral approach, with low public participation. In the 1970s and 1980s the accent moved towards more coordination and more participation. The awareness of ecological consequences increased, while the dominance of engineering solutions was still in place. In the last decade, the ascent of the sustainability concept, of environmental management, of people's participation, of integration and of good governance could be witnessed.

The key question in addressing the issue of integration is how to safeguard integration in a system of public administration that is usually organized along sectoral lines. Governments faced the problem how to draw together diverging policies, strategies and implementation mechanisms in coastal areas. They gradually came to realize that an integrated or at least coordinated approach was absolutely necessary in the management of coastal resources.

The ICZM-concept was shaped in the 1980's and obtained a political dimension during the Earth Summit in Rio de Janeiro in 1992, in the period that saw a trend towards a focus on sustainable development. Earlier experiences showed that there is no silver bullet, no single always applicable theory to guide coastal planning and management. Instead, country specific approaches have to be identified, taking into account the social, economic, cultural, administrative and political situation. Many countries have adopted integrated coastal management policies and practices. Interesting examples in Asia are Sri Lanka, Indonesia, Vietnam and The Philippines. For Bangladesh, the rationale to follow a special approach in the coastal zone was clear. Problems and opportunities in the coastal zone differ from those elsewhere. This is mostly because of the delta character of the coastal zone and the fact that many parts of the coast are remote; they have settled in comparatively recent times, with population that has to face a set of vulnerabilities. These vulnerabilities cannot adequately be addressed by a single intervention. A multi-sector, integrated approach is required.

The first initiative on Integrated Coastal Zone Management was taken by the ESCAP Secretariat and the Planning Commission of Bangladesh in 1986. A follow-up study, supported by UNDP and coordinated by the Planning Commission, was completed in 1993. Early 1999 the attention on Integrated Coastal Zone Management in Bangladesh was renewed by an international study tour of five Secretaries of the Government of Bangladesh, joined by the Director General BWDB and the Chief Conservator of Forest. The study report ("Integrated Coastal Zone Management: Concepts and Issues") was adopted by the Government and became known as the Government's Policy Note on ICZM.

The publication of the report was followed by two joint Government/donor missions that elaborated the steps in preparing an ICZM program. The mission reports marked the beginning of a series of meetings within the Government and between the Government and development partners that ultimately led in 2000 to the Integrated Coastal Zone Management Plan project, with financial contributions from the Governments of Bangladesh, the Netherlands and the United Kingdom. The project had three major outputs: the Coastal Zone Policy (approved by the cabinet on 17 January 2005), the Coastal Development Strategy (adopted by the Inter-Ministerial Steering Committee on 13 February 2006) and the Priority Investment Program (drafted in 2005 and accepted in 2006).

1.2.2 Coastal Zone Policy and Coastal Development Strategy

The Coastal Zone Policy (2005) builds on the different sector-oriented policies. It defines the goal of ICZM as "to create conditions, in which the reduction of poverty, development of sustainable livelihoods and the integration of the coastal zone into national processes can take place". The Coastal Development Strategy (2006) evolves around nine strategic priorities:

- Ensuring fresh and safe water availability (in the context of regional water resources management);
- Safety from man-made and natural hazards;
- Optimizing the use of coastal land;
- Promoting economic growth emphasizing non-farm rural employment;
- Sustainable management of natural resources;
- Improving of livelihoods conditions of the people, especially of women;
- Environmental conservation;
- Empowerment through generating and disseminating information and knowledge;
- Creating an enabling institutional environment.

Both the policy and the strategy documents provide the institutional framework, with key roles for coordinating mechanisms at the national level (the Inter-Ministerial Steering Committee and the Inter-Ministerial Technical Committee).

1.2.3 The National Water Policy and — Management Plan

The National Water Policy (1999) seeks to provide direction to all stakeholders working in the water sector for achievement of specified objectives. These objectives relate to harnessing of surface and groundwater, to availability of water to all, to management of resources for poverty reduction, to the institutional, legal and regulatory context, and to the enhancement of knowledge.

The National Water Management Plan (approved in 2004) discusses the main issues in water management under six headings: main river development; towns and rural areas; major cities; disaster management; agriculture and water management; natural environment and aquatic resources. Although the coast is not a separate category, coastal issues are mentioned under the six group headings. The plan attaches great importance to regional programs for development of water resources.

1.2.4 Bangladesh Climate Change Strategy and Action Plan

The revised Bangladesh Climate Change Strategy and Action Plan of September 2009 was issued by the Ministry of Environment and Forests (since 2018 the Ministry of Environment, Forest and Climate Change). It sketches the context (including the international developments such as the Bali Road Map) and outlines the implications and likely impacts of climate change in Bangladesh. The pro-poor adaptation strategies are built on six pillars:

- Food security, social protection and health;
- Comprehensive disaster management;
- Infrastructure;
- Research and knowledge management;
- Mitigation of carbon dioxide emissions and low carbon development;
- Capacity building and institutional strengthening.

For each pillar (or theme), a series of programs and actions is identified.

Though there are obvious similarities between the nine strategic priorities of the CDS and the pillars of the BCCSAP, it is striking that in the latter document no reference is made to the CDS. But without explicitly stating it, the approach and priorities of the CDS are endorsed by the climate change strategy. The BCCSAP expired in 2018, but, as announced in the 7th Five Year Plan (2016-2020), the intention is to work on a revised edition.

1.2.5 Perspective Plan of Bangladesh

The final draft of the Outline Perspective Plan of Bangladesh 2010-2021: "Making Vision 2021 a Reality" has been issued by the Planning Commission in June 2010 and approved by the Government in 2012. The major Perspective Plan strategies for coastal zone management (under the heading of water resources management) include, amongst others, the examination of large scale operation and maintenance (O&M) activities with regard to embankments and polders, in order to prevent salinity intrusion along the coast. It states that the different options to implement such a large-scale operation should be identified and compared, and the best way to move forward should be determined. The rehabilitation of coastal embankments should be seen in the light of the impact of climate change. The Plan further identifies desalinisation activities and enhancement of land reclamation as priority subjects. All the proposed measures are ultimately aimed at eradication of poverty, inequality and deprivation.

Since the inception of the Perspective Plan in 2010, Bangladesh has become a lower-middle-income country. As set out in the Second Perspective Plan 2022-2041, formulated by the National Economic Council in 2015, the goal is to elevate the country to upper-middle-income status in 2030 and high-income status in 2041. An essential element is the commitment to achieve the Sustainable Development Goals. The period till 2041 coincides with the BDP2100 and both plans share common goals in terms of working towards a climate resilient delta in an environmentally sustainable manner.

1.2.6 Water Act

The National Water Act of 2013 covers the many aspects of and provides the legal framework for water management. The objective of the Act is to "make provisions for integrated development, management, abstraction, distribution, use, protection and conservation of water resources". Implementation of the Act is still a work in progress. The Act is generally seen as a considerable step forward in the further development and management of water resources. It gives a legal basis to vital water management institutions as the National Water Resources Council (NWRC) and its Executive Committee (ECNWRC). Bangladesh Water Rules 2018 has been approved by the Government, and a Government Gazette notification has been published on 18 August 2018. The Rules, endorsed after a few years of the promulgation of the Act, help effective enforcement and management of water resources in an integrated manner.

1.2.7 Bangladesh Delta Plan 2100

There is a favorable policy environment for further development of coastal chars, as is shown in the Bangladesh Delta Plan 2100, approved by the National

Economic Council in September 2018. In the light of climate change, the government decided to develop a plan to the end of the century. BDP2100 combines the aspirations of Bangladesh to change its status from lower– to upper middle-income country, with a longer term integrated and holistic vision of sustainable management of water– and land resources. The document consists of separate volumes on strategy and on investments. The plan covers much more than the coastal zone (see section 1.1.1), but the strategy part gives ample attention to coastal issues, ranging from threats such as cyclones and salinity intrusion to opportunities, such as sustainable use of natural marine resources. Relevant topics for char development are integrated spatial planning, coastal land accretion and the optimal use of coastal land. Proposals for investments include 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.

The plan recognizes the extent of uncertainties, such as climate change and socio-economic developments in the country. Quite rightly, the importance of adaptive, flexible strategies is stressed. This approach requires strong institutions and a broad and reliable data base, leading to the conclusion that institutional and knowledge development are the broad, overriding priorities for the future.

1.2.8 Harmonization

There is without a doubt a highly supportive policy environment for an integrated coastal development program that seeks to reduce poverty and increase the resilience of coastal communities to cope with the multiple vulnerabilities that are so characteristic for much of the coastal zone. This support is not only given by the Coastal Zone Policy and Coastal Development Strategy but can also be derived from other policies and strategies, including the BDP2100. Many links exist between the various policy– and strategy papers: focus on poverty alleviation, significance of water management, a regional approach, priority for disaster management, infrastructure development, knowledge development and management, and capacity building and legislation. The issue at stake is not so much the differences in policies and strategies, but the harmonization of the way the strategies are made operational. This lies at the heart of the approach propagated by the Integrated Coastal Zone Management concept.

1.3 FUNDING OF COASTAL DEVELOPMENT

There are basically five sources of financing for development in the coastal zone: public sector investments; assistance from multilateral institutions and bilateral development partners; NGO contributions; and private sector investments.

1.3.1 Public Sector Investment

Public investment in development is allocated sector and department wise, for specific projects and programs. There is no regional or zonal angle to it. Government Departments prepare projects with cost estimates to implement it within a certain period of time extending from one to several years. All development projects of all sectors and Departments are listed in the Annual Development Program (ADP). Funds are allocated project-wise in the ADP on an annual basis, within the framework determined in the Five Year Plans. Given this structure of allocation of public funds, it is difficult to find out exactly how much funds are allocated to the coastal zone. To give an indication, examining the type and location of the projects included in the ADP, it is estimated that a public investment of approximately Taka 101.00 billion (US$ 1.45 billion) has been made to the coastal zone of Bangladesh over the five years from Financial Year 2005/6 to FY 2009/10. This amounts to around 10% of the total of funds allocated in that period. On an annual basis, the public sector investment in the coastal zone can thus be estimated at US $ 290 million. More recent figures were not collected, but there is no reason to assume that there was a dramatic decrease in coastal investments, given the priority coastal development was given in, for instance PRSP-II and consecutive Five Year Plans: Sixth FYP (2010-2015) and Seventh FYP (2015-2020).

A significant source of funding is the Climate Change Trust Fund. The government has issued the modus operandi of the Fund's utilisation in the fiscal year 2009-2010. Since its inception the Government has allocated nearly US$ 438 million from the Government's own resources to the fund. The fund is being utilised to achieve the pillars and action plans of the BCCSAP 2009. Ministries, departments, universities, NGOs and civil society organisations submit, in a prescribed form, project proposals at the Ministry of Environment, Forest and Climate Change (MoEFCC) for funding from the Trust Fund. A Technical Committee led by the Secretary of the Ministry reviews the proposals technically and critically, and recommends for consideration, while the Board of Trustees of the Bangladesh Climate Change Trust Fund led by the Minister for Environment, Forest and Climate Change including as many as ten ministers and six secretaries of relevant sectors, approves the projects for implementation. Burden of implementation lies with the relevant ministries, while BCCT and MoEFCC monitor and evaluate the implementation of the projects. In the water resources sector, notable achievements to date are construction of nearly 232 km coastal embankment, 14 number of cyclone shelters, 491 km of excavation/re-excavation of canals, three rubber dams, two spurs, 46 water control structures, and of 90 km of river protection works.

1.3.2 International Support

A part of the public sector funds has been and will be made available through development partners. There are enough indications from multilateral institutions and bilateral development partner agencies that proposals for projects in the coastal zone of good quality, especially the ones following an integrated approach, can count on adequate financial support. The coordination and harmonization between different sources of foreign financial assistance for coastal development has been a long-standing issue.

Efforts have been undertaken in the past to channel funds for coastal programs through one central fund. A number of reasons can be cited that to date this has not made much progress: the uncertainty of the size and nature of the portfolio of projects that will be presented; the complex and diverse nature of coastal development activities; the fact that experiences with other examples of central pooling of funds for (sectoral) programs were controversial; the administrative system in the country is not yet ready for a drastic shift from a project to a (sub) sector-wide approach, which a central pooling might entail; pooling of funds is for a number of donors not a priority under the policies applied to their country program in Bangladesh. Government officials and development partners alike were convinced that above all a pragmatic approach is required. The modality should not become an end in itself but should serve the purpose of effective delivery of services to coastal communities. It is felt that such a practical approach would mean that development partners form coalitions around projects or clusters of projects that reflect their policies and priorities in the best manner.

With the acceptance of the BDP2100 the funding landscape can be much different. The Plan proposes to establish a Bangladesh Delta Fund consisting of contributions from the side of the government (both development and recurrent expenditures), the development partners, the private sector and international climate funds. Annual expenditures for the BDP2100 program are estimated to be around 2.5% of GDP. To put this in perspective, current expenditures on water related projects amount to 0.6 to 0.8% of GDP.

The proposed fund can possibly draw on the experiences with the commitment of five development partners of US$ 110.00 million for the Bangladesh Climate Change Resilience Fund. The Ministry of Environment, Forest and Climate Change, on behalf of the Government of Bangladesh, administers the fund. From this trust fund interventions in the coastal zone are being financed, identified in the BCCSAP.

1.3.3 NGO Funding and Private Sector Investments

NGO Funding

NGO funding in Bangladesh for the period July 2009-June 2010 amounted to about US$ 484 million. It is not known how much of the funds were used for coastal communities. As we saw, the annual investments in the coastal zone of the Government were approximately US$ 290 million a year. The NGO funding in the coastal zone in the comings years is expected to increase as the Seventh Five Year

Plan and the Second Perspective Plan will be implemented with participation of the NGOs and the civil society organizations.

Private Sector Investments

Public investment in Bangladesh concentrates on the public goods producing sectors like water management, education, health, etc. However, the private sector is the main investor in other sectors. It is estimated that of the overall investments in the country, less than 20% are from the side of the government. Both the government and the private sector itself, through its Chambers of Commerce in Dhaka, Chittagong and Khulna, are promoting investments from entrepreneurs, both local and foreign, for industrial and service oriented (as tourism) activities in the coastal region. Private investment in the agricultural sector increased in the coastal zone due to the development of polders that ensure flood control, stop salinity intrusion and protect the coastal zone from storm surges. The increased security has stimulated private sector investment. Probably more attention should be given to innovative ways of attracting private money, as for instance through public/private partnerships in coastal projects. The BDP2100 notes that there has been a growing realisation that involvement of the private sector in investment and operation of infrastructure, including delta management, needs to be increased in order to meet the demands for more and improved infrastructure facilities. As opportunities are mentioned dredging, flood protection and drainage, water supply, ship building, inland water transport, land reclamation, agriculture and irrigation.

1.4 DEVELOPMENT EFFORTS IN THE ACTIVE DELTA

It would go too far to provide a complete and exhaustive list of all the development projects and programs in the coastal zone over the last years. A number of chapters in this book are primarily based on experiences and knowledge derived from a few development efforts in the central, dynaOmic part of the coast: the Estuary Development Program (EDP), the different phases of the Char Development and Settlement Project (CDSP), the Regional Fisheries and Livestock Development Component (RFLDC) and the project "Promotion of Adaptation to Climate Change and Climate Variability in Bangladesh".

1.4.1 Estuary Development Program (EDP)

The Dutch supported Land Reclamation Project, spanning over a period of 14 years (1977 to 1991) was one of the early systematic efforts in the field of land reclamation and estuary development. It concentrated on both reclamation of land as on further development of newly formed land. After its completion, similar objectives were pursued in two different projects, the Meghna Estuary Study and the Char Development and Settlement Project.

The Meghna Estuary Study (1995 to 2001) carried out marine surveys as well as implementation of a number of erosion control and land accretion projects on a pilot basis. A BWDB Task Force reviewed the findings and observations of all MES studies and identified 19 potential sites to construct cross dams in order to assist and accelerate the natural process of land formation in the Meghna Estuary. The Estuary Development Program, as the successor of MES, commenced in 2007 and was completed in 2011. The main activities of EDP were updating of surveys, investigation and design of potential cross dams and erosion control schemes, as well as preparation of investment-oriented projects.

Reclaiming new land in the coastal zone is a strategy in BDP2100 and building cross dams at strategic locations is promoted.

1.4.2 Char Development and Settlement Project (CDSP)

CDSP began its first phase in 1994 in three chars in Noakhali District (Char Majid, Char Baggar Dona II and Char Bhatir Tek) that were all turned into polders, with three implementing agencies: the Bangladesh Water Development Board (BWDB), the Local Government Engineering Department (LGED) and the Ministry of Land. In the second phase, activities were expanded to chars in four Districts of Chittagong, Feni, Noakhali and Lakhsmipur, while two more implementing organizations joined: the Department of Public Health Engineering (DPHE) and the Department of Agricultural Extension (DAE). In that phase the project worked also in areas that were left unprotected. In the third phase, ending at the end of 2010, interventions were concentrated on Boyer Char in Noakhali District. The Forest Department became the sixth partner agency. As a part of the overall CDSP effort, local NGOs are working in the same area as the government component of CDSP. A fourth phase has been implemented in five chars in Noakhali and Chittagong Districts, with an implementation period from 2011 to 2017, plus a bridging period till 2020. BDP2100 recommends the preparation and implementation of a fifth phase. CDSP is being funded by the Bangladesh and Dutch Governments, while IFAD joined in the fourth phase.

CDSP has become known for its institutional arrangements. They safeguarded the approach of the project towards integration, focusing on shared planning and individual but coordinated implementation, both with participation of the households involved. In the system, the abovementioned government departments play a dominant role, with coordination mechanisms at several levels. NGOs deliver services, complementary to the ones provided by the government. Local government institutions and community-based groups are involved at an early stage in planning, and participated in implementation as well. The coordination mechanisms were: the Inter-Ministerial Steering Committee (national, Secretary level; policy oriented) and the Project Management Committee (agency level, Project Directors as members, implementation oriented). At field level agreements exist between field level groups and government agencies, supplemented by ongoing bilateral consultations.

1.4.3 Regional Fisheries and Livestock Development Component (RFLDC)

On the basis of the experiences and success of the Danida-funded Mymensingh Aquaculture Extension Project (MAEP), located in the north-central part of Bangladesh, the Patuakhali-Barguna Aquaculture Extension Project was initiated in 1997 in the southern part of Barisal Division, followed in 1998 by the Greater Noakhali Aquaculture Extension Project (GNAEP). This project covered 15 Upazilas in the three districts of Feni, Lakshmipur and Noakhali. Several of these Upazilas cover extensive char areas. The Smallholder Livestock Development Project in the Five Southern Districts (SLDP-2) began in 2000 and was operational in the three just mentioned districts as well as two Districts of Barisal Division.

The objectives and type of interventions were combined in one project in 2007, the Regional Fisheries and Livestock Development Component (RFLDC), Noakhali, operating in Greater Noakhali, including the char areas. The main objective of this project is income generation for farmers through increased and sustained productivity in aquaculture and animal husbandry, as well as capacity building of local institutions. RFLDC is a component of Danida's Agricultural Sector Program Support, Phase II (ASPS II), which ended in 2013. As a result of changes in Danida policy, the fisheries and livestock sector projects were absorbed into a country-wide Integrated Farm Management Component of the subsequent Agricultural Growth and Employment Program, with no specific project presence in Greater Noakhali. As will be seen in Chapters 5 and 6, RFLDC supported CDSP IV in widening its agricultural sector activities to cover aquaculture and animal husbandry in the chars.

1.4.4 Promotion of Adaptation to Climate Change and Climate Variability

The project started in December 2004 in two Upazilas of Noakhali District, Subarnachar and Sadar. It completed two phases and ended in September 2008. The project consisted of studies and pilot action research, aiming at enhancing adaptation of local communities to climate change. The project also developed initiatives aiming at influencing policy and at institutional development. Extensive Participatory Vulnerability Assessments (PVA) have been carried out, in order to understand and address concerns of the families in the selected areas. As a pilot to identify suitable technologies, six disaster resilient homes have been constructed or improved, as well as two schools. In addition, six robust fishing boats have been designed and built. The boats are able to withstand the rougher seas that are one of the consequences of climate change. Field testing of saline tolerant varieties in demonstration plots and training workshops on cyclone warning systems, were other components of the project. The project was implemented with support from the Netherlands Climate Change Assistance Program.

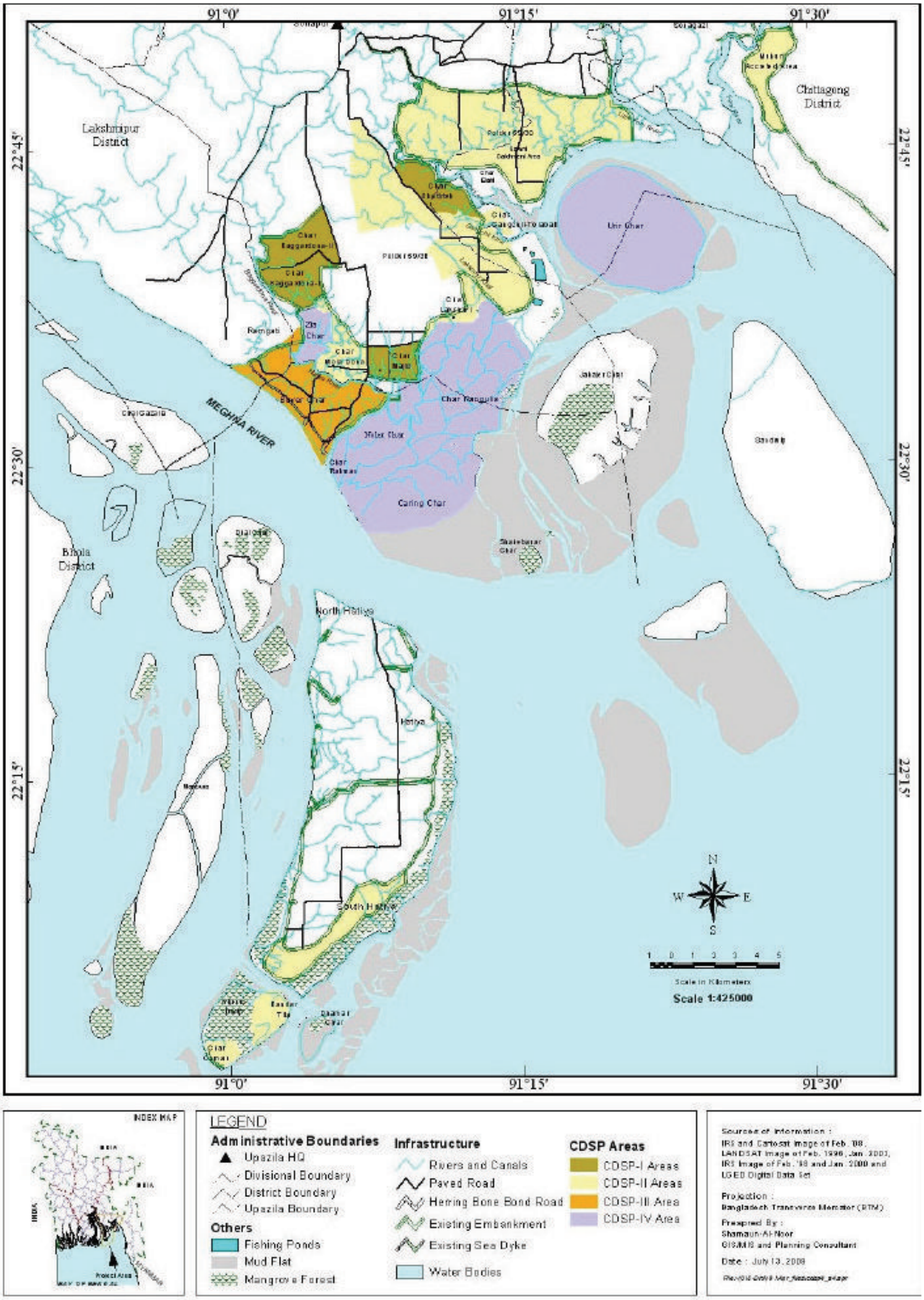

Figure 1.2: Areas of CDSP, RFLDC and Promotion of Adoption to Climate Change and Climate Variability Project

1.5 STORY LINES OF THE BOOK

This book seeks to inform the reader about the emergence of new lands and the use of those lands in the estuary of the Ganges-Brahmaputra-Meghna rivers system. This introductory chapter aims at setting the stage for the remaining part of the book. To repeat the salient features of the context:

- The Meghna Estuary is part of the central region of the coastal zone of Bangladesh; it is a dynamic delta with a permanent process of accretion and erosion, resulting in constantly moving coastlines.
- Coastal communities are confronted with multiple vulnerabilities; the delta shows a nearly continuous migration of erosion victims to newly emerged chars.
- Knowledge of long term trends in the delta is increasing, but uncertainties about the impact of climate change prevail.
- The Government has created a positive policy environment for coastal development.
- Development partners have shown interest in the coastal zone and indications are that this will only intensify in the coming years, not in the least because of the anticipated impact of climate change on coastal areas in the country.

In the book, three story lines will be followed. One is a more or less chronological line, focusing on natural and biological resources. It starts with the water and sediment carried by the three main rivers to the Bay of Bengal, and the processes of land formation and — stabilization, at the same time erosion in other places (Chapter 2). It continues with the question whether to make a polder of the land or leave it unprotected, while giving attention to the all-important issue of operation and maintenance of infrastructure (Chapter 3). Forestry plays a key role in the first stages of land development, has a function in mitigating the effects of wave action and storm surges, and can create income streams for settlers (Chapter 4). The story is taken further to later phases, when the economic uses of the land for fisheries (Chapter 5), livestock (Chapter 6) and agriculture (Chapter 7) gain in importance. In these three chapters the potential of these sectors for improving economic conditions and making decent livelihoods sustainable, are highlighted.

A second theme is the narrative about people and institutions. This theme is reflected to a greater or lesser extent in the same chapters as just mentioned (Chapters 3 to 7). It comes back in the account given about the way people settle on the new lands and about the process of issuing official land titles to landless households (Chapter 8). The people-oriented line is extended and expanded in Chapters 9 and 10. Chapter 9 is on the question what the consequences are of development interventions for the settlers and for the social fabric in the chars.

How communities are coping with and adapting to the effects of climate change is dealt with in Chapter 10.

Climate change is the third narrative in the book. It is touched upon in the subsequent sectoral chapters. As mentioned, Chapter 10 is devoted to the ways communities are coping with and adapting to the effects of global warming. Chapter 11 dwells on the longer term impact of climate change on the physical, in particular morphological, processes in the Meghna Estuary.

In the three last chapters, the themes are as it were brought together while the focus shifts to the future of coastal development. Chapter 12 is on the Bangladesh Delta Plan 2100 in general, while Chapter 13 focuses on the relevance of the Plan for the coastal zone. The last chapter makes an effort to summarize the main findings of the book and ends with an agenda for the future.

As reflected in the title, the overall theme, though, is one of dynamics. In literature the notion can be found that the history of Bangladesh can be seen as a history of moving frontiers. This book highlights a part of the land-water frontier in the Meghna Estuary, a particular section of the coastal zone, a section that in itself embodies the concept of dynamics.

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Chapter 2

Land Formation and Erosion in the Estuary

Zahir-ul Haque Khan, Fortunato Carvajal, Md. Mahfuzur Rahman

2.1 INTRODUCTION

This chapter intends to explain the rather complex processes that lead to accretion of new land and the loss of existing land, and the possible interventions aimed at accelerating the natural accretion process. It starts with an overview of the long term trend of the development of the Meghna Estuary (section 2.2) and with the factors that play a dominating role in the physical process taking place (2.3). Section 2.4 provides information on the development of the last fifty years, a period in which interventions had a considerable impact on formation of land. The focus is shifted to the future in section 2.5, dealing with potential land accretion schemes. The chapter closes with some thoughts on land management in the period directly after the land has accreted (2.6) and with concluding remarks (2.7).

2.2 LONG-TERM HISTORICAL TREND OF MORPHOLOGICAL DEVELOPMENT AND RIVER FLOWS

Generally, deltas and estuaries are known as areas of a net deposition of sediment either carried by the river or supplied from the sea by tidal action. The natural morphological development in the past is shown in the historical maps (Figure 2.1). The growth of the delta and accretion of land in the estuary is a continuous and a very gradual natural process, interfered by the dynamics of the ever changing courses of their channels. The comparison of the satellite image of 2008 with the map of 1779 (J. Rennell) shows a significant change of the system of channels and river courses, and of shifting of islands. However, a fairly stable coastline is seen west of the Tetulia River. East of the Tetulia River, a general tendency of seaward growth can be recognized, particularly at the south of Bhola island, in the region of Hatiya and Nijhum Dip islands, along the coast of Noakhali District and in the region of Sandwip, Urir Char and Jahazer Char islands. The process of land accretion is dominant in the estuary, however, severe erosion is also observed along the east coast of Bhola island, the north coast of Hatiya island, and the west coast of Sandwip island. This erosion is the result of southward migration of the coastline and westward migration of the Meghna Estuary. Comparison of maps of 1945 and 1973 clearly shows the changes which have taken place in the past. In 1940 the Lower Meghna River was bifurcated just north of Bhola Island. The eastern branch was debouched into the Sandwip and Hatiya channels. The other branch was flowing towards the south and mainly debouched into Shahbazpur channel, with a secondary channel via the north of Hatyia island to Hatiya channel. Over the years, the eastern branch of the Lower Meghna deteriorated and silted up, and finally lost its function completely when two cross-dams were constructed, in 1957 and 1964 respectively (see section 2.4.1.). Accretion from the mainland of Noakhali in southern and south eastern direction continued, moving the coastline more than 50 km into the Bay of Bengal.

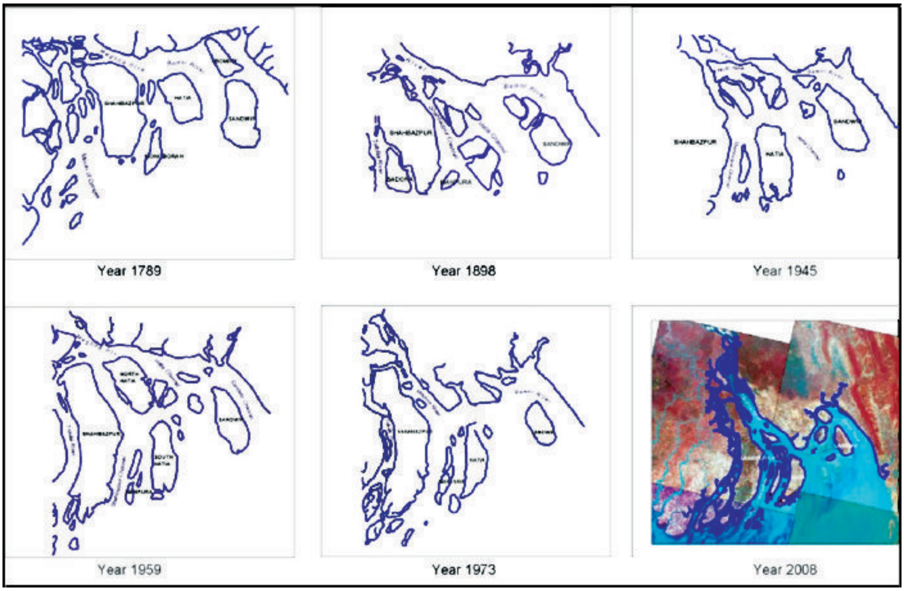

Figure 2.1: Historical Trend of Morphological Development in the Estuary

2.3 FACTORS INFLUENCING THE ACCRETION AND EROSION PROCESS

2.3.1 An Overview

The area of the Meghna Estuary in Bangladesh is the only active delta-forming estuary among the several other estuaries that exist along the coast of the Bengal basin. As described in Chapter 1, it forms the central region in the coastal zone of Bangladesh and is the most dynamic part of the coast. The estuary is being shaped by an interaction of physical processes. The interactions between them are very complex and usually non-linear. There are a number of factors that play an essential role in what is happening in the estuary. The most important ones are the sediment load, its transport and its distribution (dealt with in 2.3.2). Investigations have shown that upland flow, tidal forces and estuarine circulation are important factors as well (2.3.3 and 2.3.4). The concentration and distribution of sediment in the river channels and nearshore are important variables in determining delta morphology. Understanding sediment composition across different transport mechanisms also provides insight into the reworking and accretion of material across the delta.

Some factors have a long term (hundreds to thousands of years) effect on the estuary, such as shifting of the river mouths as a consequence of the delta building processes, changing of the base level, and climate change. Also, natural hazards like earthquakes, cyclonic storm surge may have an impact.

2.3.2 Sediment Transport

The sediment load flowing from the Ganges-Brahmaputra-Meghna river system into the Bay of Bengal is essential for the development and sustainability of the coastal physical system. Erosion would have eaten away the coast, if the continuous supply of sediment would not have been there.

The total annual sediment discharge into the Lower Meghna is on average about 1,100 million tons per year. There are annual fluctuations, varying from a discharge of 800 million ton to 1,400 ton. Of the sediment load, about one third is deposited on the riverine flood plains of the middle-delta, of great importance for maintaining land elevation and soil fertility. Two thirds, or roughly 700 million tons, reach the Meghna Estuary and become subject of a complex interplay between different forces. A sizable part of the sediment that reaches the estuary is taken to the west by coastal currents. Most of it will enter the Swatch of No Ground and is subsequently transported into the deep ocean, leaving the estuarine system. About one fifth of the original supply of 1,100 million tons is retained in the Meghna estuary and forms the material for land accretion in the central part of the coastal zone.

About 70% of the total river discharge consists of fine sediment. The sediment discharge mainly comes from the Brahmaputra (Jamuna) and Ganges rivers and for a small part from the Upper Meghna river basin. Studies have shown, the sediment discharge is strongly related to the river discharge (see section 2.3.3) and the availability of sediment. The analysis of morphological changes of the estuary over the period from 1973 to 2000 indicates that the net gain (or loss) of land is strongly related to the river discharge as well. For example, in the period 1996-2000, the erosion was more pronounced than in other periods, because very high discharges occurred in 1996 and 1998. In the year 2018 and 2019 accretion was dominant. Within the estuary the river borne sediment is trapped by tidal pumping and residual circulation and mixes with the material brought in from sea. In the Meghna Estuary the maximum depth sediment concentration varies from 0.5 gram per liter to 9 gram per liter. In order to devise long-term development plans for the coastal area, it is of immense importance to know the upland and marine sediment inflow and how much sediment is exactly retained in the estuary. The other important questions are about sediment distribution in the estuary, and what the influence is of tidal and estuarine circulation (see section 2.3.4).

Recent studies show an increasing trend of sediment supply to the GBM delta. Darby and co-authors apply the model Hydrotrend to assess the impact of different IPCCC climate-change scenarios and monsoon projections. The model results suggest that the supply of fluvial sediment to the GBM delta could increase to by 15-50% in the next 50 years under a strengthened monsoon and increased water discharge. Several climate models do suggest a strengthened summer monsoon under a warming climate, but there is considerable uncertainty. In contrast to the projected increase in sediment supply due to climate change, upstream human interventions could cause a significant decrease. Furthermore, due to the gradual increase of water level in the Bay of Bengal, due to sea-level rise, the impact on the water levels in the coastal area and the estuary will be noticeable, as the water level will increase due to influence of the tides, increasing the occurrence of flooding and modifying the present platform of channels and islands in the area, accelerating the morphological processes of erosion and accretion in the estuary.

2.3.3 Discharges and Water Levels

The Lower Meghna River conveys to the Bay of Bengal the melt– and rainwater from the Ganges and the Brahmaputra basins (combined in the Padma river), and from the Upper Meghna basin. The discharges of these three major rivers dominate the river inflow in the Meghna Estuary. The combination of strong river and tidal flow produces a complex flow pattern in the estuary.

The trend of annual minimum, mean and maximum water levels and discharge is presented in Figure 2.2 The trend of maximum water flow in the Bramahputra/ Jamuna and Ganges is increasing; in contrast to the increasing trend in these two rivers, maximum discharge in the Upper Megna at Bhairab shows a decreasing trend. The average and minimum water flow show a decreasing trend in the Ganges river. The minimum discharge in the Brahmaputra river (Jamuna) at Bahadurabad does not show any trend. An increasing trend is seen in the maximum water level at the Jamuna river, but there is no significant trend in the Ganges river. The minimum water level of the Ganges River shows a decreasing trend at Hardinge bridge. These diverging trends in annual characteristics of discharge and water level indicate enormous river dynamics that influence the coastal area and estuary. However, the dry season flow of the Ganges is controlled at the upstream that leads to a decreasing trend of the Ganges flow in the lean period.

Further analysis illustrates that the maximum discharges over the period 1967-1973 and over the period 1989-1994 were relatively low compared to those of the period 1984-1988 and 1995-1998. The period 1984-1988 and the period 1995-1998 were relatively very wet seasons characterized by extremely high water levels and river discharges.

The dry season (October-March) is the calm period in the estuary. The wind is weak, and the river discharge is much lower than during the monsoon. Water movement in the estuary is mainly forced by the tide entering from the Bay of Bengal. Monsoon (June-September) is the dynamic season in the estuary. The south-westerly monsoon wind is steady, and the river discharge is high. Furthermore, the mean water level is higher than during the dry season. The monsoon season is critical with respect to high water-levels, sedimentation and accretion.

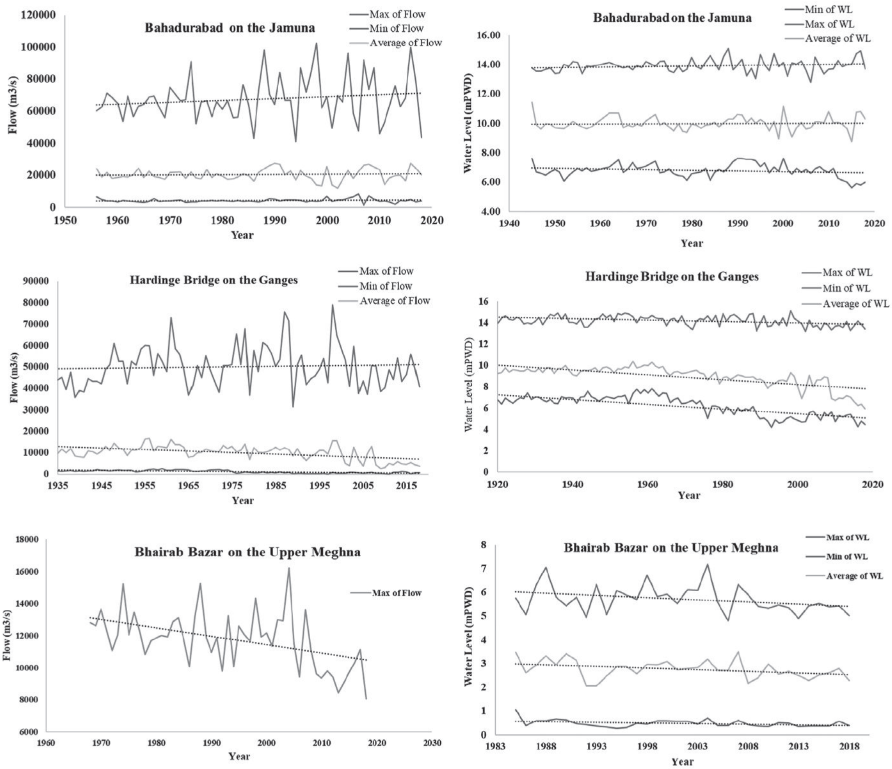

Figure 2.2: Trend in Water Level and Discharge of the Brahmaputra, Ganges and Upper Meghna Rivers

2.3.4 Tidal Characteristics and Estuarine Circulation

The tide in the coastal area of Bangladesh is semi-diurnal, i.e., there are approximately two high tides and two low tides within a 24-hour period. The period of one tidal cycle is 12 hours and 25 minutes. The tidal wave from the Indian Ocean travels through the deep part of the Bay of Bengal and moves toward the coast of Bangladesh approximately from the south. The tidal wave is arriving from the south, reaches at Hiron Point (south of Khulna) and at Cox's Bazar (south of Chittagong) at the same time. The extensive shallow area in front of the large delta causes some refraction and distortion of the tidal wave. Reflection of the tidal wave also occurs in the Sandwip Channel, contributing to a significant amplification of the tidal wave. The tidal range, the vertical difference between the high tide and the succeeding low tide, is the highest in the Sandwip channel due to the funnel shape of the channel and the refraction of the tidal wave. The observed variation of tide from spring tide to neap tide during dry season at the east side of Jahazer Char is shown in Figure 2.3.

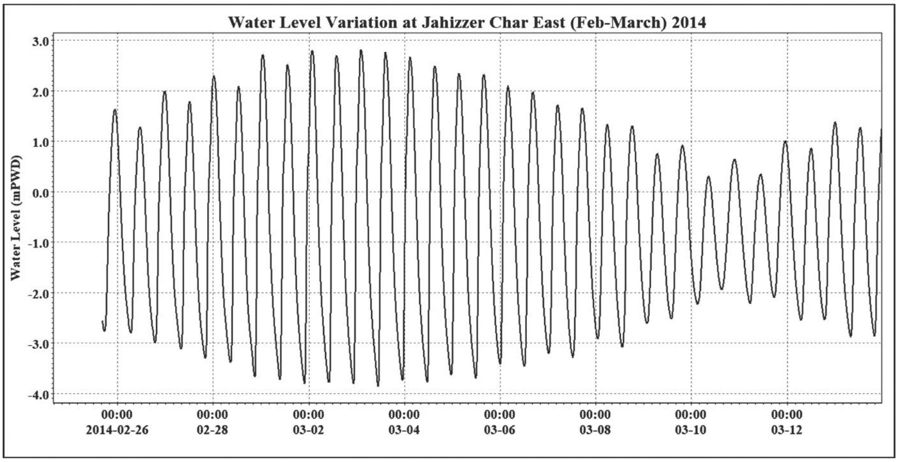

Figure 2.3: Variation of Tide in the Meghna Estuary Near Jahazer Char

The tidal range at the north end of the Sandwip channel varies from 4 m to 8 m from neap to spring tide. The highest tidal range and lowest water level is usually observed during spring tide in the dry season. The tidal range in the coastal area can be classified as follows:

West coast of Sandwip and Hatiya channels	Macro tidal: Tidal range > 4m
South Bhola- West coast and Hatiya North	Meso tidal: Tidal range: 2-4m
Tetulia river — Chandpur	Micro tidal: Tidal range: 0-2m
Sandwip channel and north coast of Urir Char	Hyperideal: > 6m range

The wind affects the tidal flow and sediment transport, the exact quantification of which is difficult to determine. The tides cause the fresh water and riverine sediment that enter into the estuary through the Lower Meghna River to mix with the sea water. The tides are semi-diurnal in the estuary, but the tidal ranges vary over the estuary from micro to macro ranges. This mixing process of the fresh water determines the salinity distribution in the estuary. The fine and coarse sediments are distributed in the estuary by tidal circulation, although salinity has a strong influence on the distribution of fine sediment as well.

The most important question is about the sediment distribution in the estuary. Bathymetric surveys, carried out in 2014, have shown the largest net accretion in the area between Noakhali and Sandwip and south of Sandwip. Other areas with net accretion could be found at the south side of Bhola and Hatyia islands. Net erosion occurred along the bank of the Meghna, roughly between Chandpur and Ramgati. This supports the distribution of sediment flow by tides. It implies that tidal circulation plays an important role in sediment distribution in the Noakhali-Sandwip area. In this regard, the Sandwip Channel is very crucial.

2.4 ACCRETION AND EROSION OVER THE LAST SIXTY YEARS

2.4.1 The Noakhali Cross-Dams

As we have seen, accretion and erosion in the Meghna Estuary is a continuous and gradual natural process, influenced by upland flow, sediment transport, and tidal dynamics. To a lesser extent wind, waves, salinity and cyclonic storm surges, are also factors in the process. These hydrodynamic factors and their interaction shape the morphology of the estuary. As a result, siltation in channel-beds, shoreline erosion, shifting of thalweg and finally shifting of channels are taking place. In Bangladesh, land reclamation by closure of channels and by cross-dam construction in order to accelerate the natural accretion process, started in 1956-57. The first such dam, with a length of 13 km, was built over the shallow eastern branch of the Meghna river. It connected the mainland of Lakshmipur with the island north Hatiya (presently Ramgati) in 1957. This dam is known as Noakhali cross-dam no. 1. The dam resulted in rapid siltation in an area of 21,000 ha. Agricultural development started in 1965. The second dam (Noakhali cross-dam no. 2) was constructed in 1964. The dam connected the mainland at 6.5 km south-west of Sonapur railway station with Char Jabbar. The length of the dam was about 30 km. An area of about 79,000 ha was reclaimed due to this cross-dam no.2. Combined, around 1,000 square km of land was reclaimed due to the construction of these two cross-dams. The process of accretion continued resulting in attachment of other small chars to Char Jabbar and Noakhali mainland. Over the years the coast line has been shifted about 55 km towards sea as a consequence of new accretion. This process of growth, i.e., net accretion is still going on.

In February 1985, more than 20 years after Noakhali cross-dam no. 2, the Muhuri closure dam was constructed across the outfall of the Muhuri river. As a result, 100 square km of land downstream of the closure was accreted within a short span of time. The new land is known as Muhuri Accreted Area.

2.4.2 Erosion and Accretion

Under the Meghna Estuary Study (see section 2.5.1) an estimate was made of erosion and accretion for the period 1973-2000, based on analysis of satellite images. During this period 863.66 square km were eroded, while 1371.68 square km were accreted. The net accretion of 508.02 square km is equivalent to a rate of 18.8 square km a year. Recently, a similar exercise was carried out for the period 2017-2019. During this period 200.68 square km were eroded, while 229.31 square km were accreted. Net accretion rate of 14.32 square km per year. Figure 2.4 depicts the erosion and accretion in the period from 2017 till 2019.

The accretion dominated around islands south and south-east of Noakhali mainland, Jahazer Char and south-west of Bhola. Urir Char migrated towards the north during this period, while the size of Sandwip was reduced due to erosion along its periphery. Natural accretion in recent years is higher compared to that in the past. This further encourages efforts to accelerate the natural process by engineering interventions in order to gain more land.

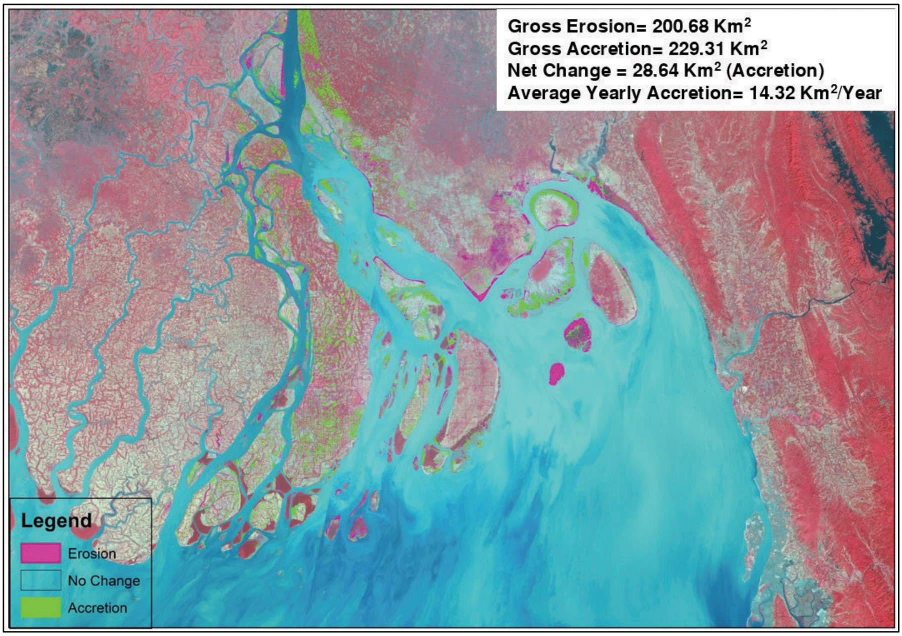

Figure 2.4: Erosion and Accretion in the Meghna Estuary during 2017-2019

2.4.3 Changing Shoreline: From Water to Mudflats to Land

Shoreline is a line that demarcates land and water in the coastal area. There is no straightforward way to demarcate these two parameters of the Meghna estuary area from the satellite images. The Meghna Estuary is a very dynamic system — erosion and accretion on the scale of several hundred meters is a very common fluvio-tidal process in this area. In places where erosion occurs, there is a sharp boundary between land and water. A major part of the landmass in the estuary consists of newly accreted land. Due to the semi-diurnal tidal variation within a range of several meters, the existence of very wide (several hundred meters to a few kilometers) intertidal mudflats makes the demarcation very difficult and uncertain. Moreover, the boundaries of the land or intertidal mudflats are changing continuously. This adds to the complexity of delineating shorelines. The landcover map extracted from analysis of the images of 2001 and 2008, as shown in Figure 2.5, gives a composition of water, mudflat, land, sand and dense vegetation.

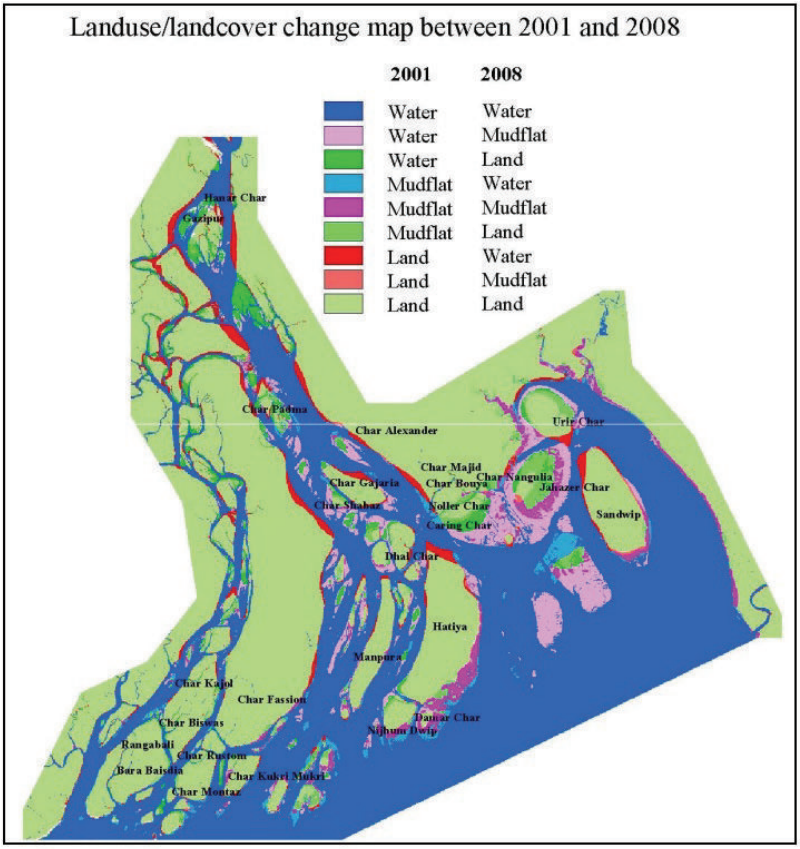

Figure 2.5: Land Use and Land Cover Change Map between 2001 and 2008

In 2001, the total mudflat area within the study area was 78,556 hectares, which was about 5.2 percent of the total study area. From an analysis of the satellite images of 2008, the total mudflat area was found to be about 96,985 hectares (6.4 percent of the total study area). Between 2001 and 2008, the mudflat area within the study area was increased with about 1.2 percent. The total land area within the study area was 665,077 hectares in 2001 and 689,128 hectares in 2008. This means an increase from 43.9% to 45.5% from the total study area. Within the total area, the land with dense vegetation, especially the mangrove forest area, was reduced from 3.1 percent to 2.7 percent. This might very well be due to illegal encroachment by settlers (see Chapters 4 and 8).

2.5 CURRENT AND PLANNED ACCRETION SCHEMES

2.5.1 Subsequent Survey– and Intervention Programs in the Estuary

Over the years, the Government and development partners have recognized the opportunities offered by land accretion. It obviously provides the country with more land (a "bigger Bangladesh"), that can serve to mitigate the population pressure and benefits the food production. Land accretion provides protection for the hinterland against natural disasters as a result of storm surges and cyclones, though drainage problems in the land behind the coast might become more severe because of the longer drainage path. Accretion is also seen as an effective tool to combat the consequences of sea level rise, caused by climate change.

As indicated earlier, currently natural accretion is going on in a number of locations in the Meghna Estuary, i.e., at and around Sandwip, Urir Char and Jahazer Char, along the Noakhali coast, south of Bhola Island, south of Nijhum Dip and along the east coast of Hatiya island. The natural accretion rate exceeds the erosion rate in the estuary, as was described in section 2.4.2 New accretion of land can be achieved by an engineering intervention, aimed at decreasing the current water velocity in a channel by reduction of the tidal prism and increasing the natural accretion process. The most common approach is the closure of a channel by constructing a cross-dam. Closing off a secondary channel by constructing a cross-dam sometimes serves two purposes; it causes gradual local accretion and it serves as protection against erosion caused by the tidal flow, since the velocity is reduced. For a example, a cross dam between Urir Char and Noakhali mainland can accrete land and mitigate the erosion at the north east coast of Noakhali (Char Elahi). Over the last decade, the significance of land reclamation as a method to cope with sea level rise has been brought to the forefront.

The impact of the two Noakhali cross-dams of 1957 and 1964 (see section 2.4.1) and ever progressing survey methods, led to a program of investigations in the lower Meghna Estuary under the Dutch aided Land Reclamation Project (LRP) and Meghna Estuary Study (MES) in order to have better understanding of erosion and accretion processes and to identify potential areas of land reclamation. A Task Force of the Bangladesh Water Development Board reviewed the findings of LRP and MES studies and submitted a report in June 2003. The Task Force identified 19 potential cross-dam sites for accelerating the natural processes of land accretion in the coastal area of Bangladesh. The Task Force also prepared an action plan for implementation, in phases, of the identified priority interventions. As a follow-up, a five years program, the Estuary Development Program (EDP), started its activities in the Meghna estuary in March 2007, again with support from the Dutch government. EDP aimed at updating hydrographic survey data, undertaking investigations and preparing designs of potential cross-dams, as well as implementation of potential erosion control and accelerated land accretion schemes. The project area of EDP is depicted in the Figure 2.6 EDP project suggested.

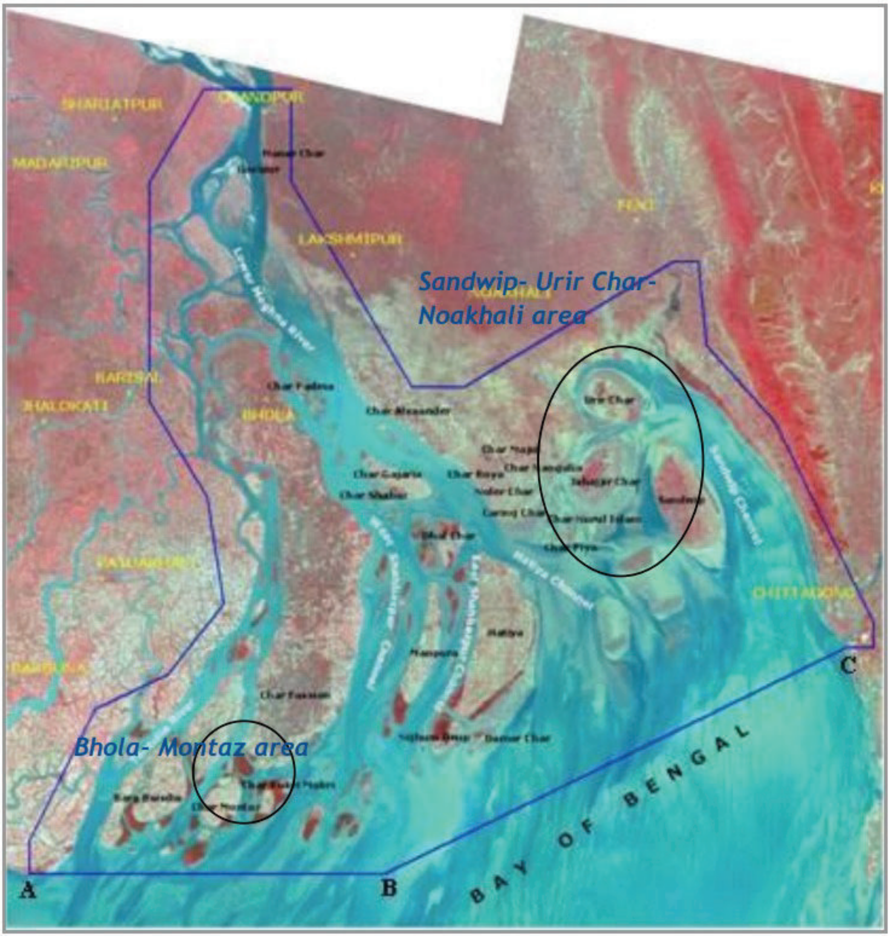

Figure 2.6: Project Area Estuary Development Programme (Meghna Estuary)

2.5.2 Potential Land Accretion Projects

Out of the 19 locations identified by the Task Force of the BWDB, based on previous studies of LRP and MES, EDP identified four potential cross-dams as having the highest priority. The selection was done after a detailed analysis of survey data and results of model studies, field visits and stakeholder consultations. These cross-dams are Char Bestin, Char Islam-Char Mainka, Char Mainka-Char Montaz (all in the Bhola-Montaz area, see Figure 2.7) and Sandwip–Urir Char-Noakhali mainland (the so-called SUN cross-dams). By April 2010, the Char Bestin cross dam was implemented under EDP. The next section will elaborate on the SUN-cross-dam.

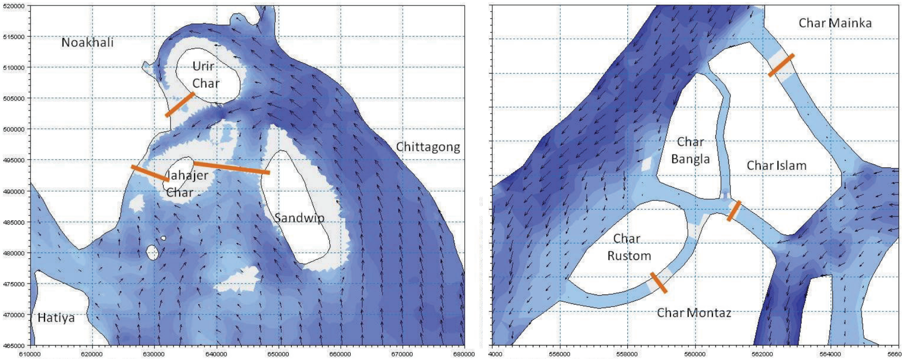

Figure 2.7 Location of Potential Cross-Dam Identified in the EDP Project

2.5.3 Development of Sandwip-Urir Char-Noakhali Accretion Area

Since its emergence, Urir Char has been growing and shifting its location from south to north. The increase in the area of landmass has not been uninterrupted. The rate of increase was around 4.7 km2/yr during 1973-84 and later during 1984-96 the rate slowed down to 0.6 square km/yr. From 1996, the rate of enlargement of Urir Char increased again to 2.85 square km/yr, and from 2001 the prevailing rate of increase was 2.45 square km/yr. If the present enlargement of Urir Char continues in the near future, its area would be more than 125 square km within the next 10 years. Figure 2.8 shows the location SUN cross-dam and potential land accretion extent.

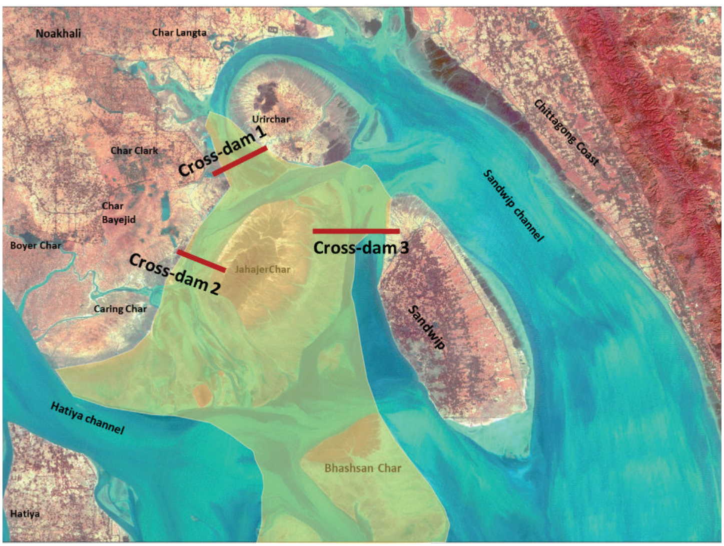

Figure 2.8: Location of Cross-Dams between Urir Char, Noakhali, Jahazer Char and Sandwip with Projected Reclamation of Land

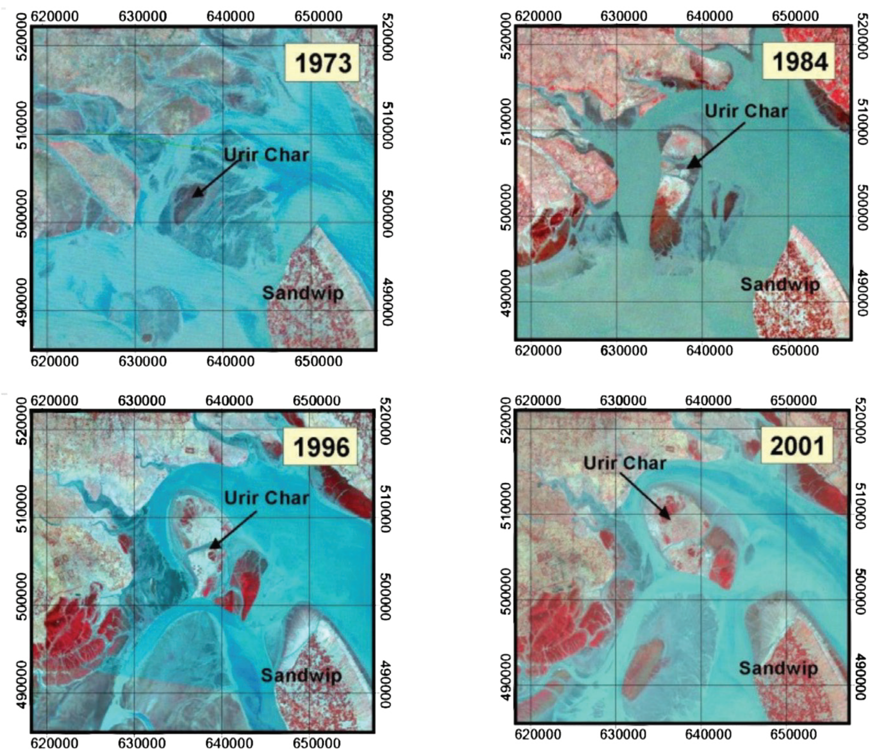

Figure 2.9: Development of Urir Char and Surrounding Areas

During the last two and a half decades, bank erosion has been continuing at the southern part of Urir Char, resulting in a northward shifting of several kilometers since 1984. The erosion at the southern tip of the char is continuing, although at a slower rate. The erosion and accretion at and around Urir Char, Subarnachar, Mirsharai, north of Sandwip, Jahazer Char) in the years between 2017 and 2019, is shown in Figure 2.9.

Accretion was the dominating process during 2017-2019 (see Figure 2.4). It contributed to the formation of a continuous mainland at Surbarnachar. The mainland extended southwards, Jahazer Char was formed. Urir Char developed and shifted towards the north, and new land emerged along the shoreline of Mirsharai. Erosion and accretion had occurred intermittently along the boundary of Sandwip Island. The magnitude of erosion in this area, however, was small compared to accretion, but it was persistently concentrated in particular areas. Since 1984, erosion especially occurred at the southern boundary of Urir Char and at Companiganj on the mainland. The shifting of Urir Char towards the north mainly caused erosion along the coast at Companiganj.

In 2009, IWM carried out a survey and a hydrodynamic and morphological modeling study in the Sandwip-Urir Char and Noakhali area, to select suitable locations of cross-dams between Sandwip, Urir Char, Jahazer Char and Noakhali. The study suggested suitable locations for three cross-dams for land reclamation, which would not have any adverse impacts on erosion and drainage of the Noakhali area. The location of cross-dams is shown in Figure 2.8 It is expected that about 500 km2 of new land will be accreted in 25 years. As a result, the coastline would be shifted further south towards the sea.

In September 2010, BWDB started to prepare a project for implementation of the Urir Char — Noakhali cross-dam, to be funded by the Climate Change Trust Fund of the Government of Bangladesh (see Chapter 1), which has not been materialized.

The future plan of implementation of cross-dams also includes the construction of cross-dams between Jahazer Char and Noakhali mainland, and between Sandwip and Jahazer Char. in this regard a Technical Committee was formed in July 2020 by Ministry of Water Resources.

Bangladesh Delta Plan 2100 also includes investment project on land reclamation in the Meghna Estuary (see Chapter 13).

2.6 THE USE OF LAND IN ITS EARLY STAGES

According to existing policies, newly emerged land will be turned over to the Forest Department for a period of 20 years (see Chapter 8), mainly in order to accelerate the stabilization of the new land through the plantation of mangrove forests. In many cases however, this period is shortened due to illegal encroachment by settlers. The great majority of these settlers have lost their land somewhere else in the region, due to erosion. This demonstrates that the physical processes of accretion and erosion, have considerable social consequences. Coastlines are moving, causing people to move as well, from eroded lands to newly accreted chars. Chapter 4 (on forestry development), Chapter 8 (on land settlement) and Chapter 9 (on economic, social and institutional transformation) all give ample attention to the phenomenon of migration and of encroachment of forests. All these chapters come to the conclusion that there is a need for a structured land management system for the period between the time that the land emerges and the moment that the land is officially allocated to individual households and Government agencies (for infrastructure used by the public). The challenge is not to stop at engineering interventions that lead to accelerate accretion of land, but to go beyond that and design a system of governance for the land, once it has emerged.

2.7 CONCLUDING REMARKS

Monitoring

Yearly monitoring of the coastal area generates valuable information on the dynamic physical and anthropogenic processes that shape the estuary. Moreover, it is instrumental to update and fill the knowledge gap in order to provide timely assistance to decision makers on devising coastal development programs and prioritizing physical interventions to both secure and make optimal use of land accreted to mitigate sea-level rise impacts in the area. Monitoring of sediment transport and distribution, land accretion, erosion, tide, drainage conditions and salinity at locations with land accretion potential will provide data and knowledge on overall coastal and estuarine processes. The monitoring efforts should be intensified and be expanded to a larger area.

Engineering Interventions

Engineering interventions as closing off estuary channels and constructing cross-dams between islands, and between the mainland and islands, have proven their value in the past (especially the two Noakhali cross-dams). With a view on the benefits of land accretion (settlement of people, agricultural production, safety of the main land, coping with effects of sea level rise), the planned program for such schemes must be taken up with priority and must be further expanded. The fact that BDP2100 supports investments in land accretion efforts, is encouraging.

Follow-Up of Land Accretion

Activities aimed at accretion and protection of land in the Estuary, should have a follow-up in a well-designed integrated land management system, with long term vision, aimed at serving both the requirement for land for people to settle on and the further maturing and stabilization of newly emerged areas. Integrated development programs, adhering to the principles of Integrated Coastal Zone Management, should start, as soon as the land is elevated and stable enough to be inhabited safely. The need for forests as an effective protection against cyclones and storm surges must be fully taken into account by such programs.

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Chapter 3

Unprotected Areas, Polder Development and Operation & Maintenance (O&M)

Dr. Bart Peerbolte

3.1 INTRODUCTION

Empoldering of coastal lands is only feasible after a long time of deltaic growth and natural rising of land. As also described in Chapter 1, in the early stages there are many environmental threats to the inhabitants: frequent high tides and storm surges, saline soils and groundwater, fresh water scarcity; and extremely high wind velocities and intensive rainfall when tropical storms and cyclones cross the area. Ideally the natural process of accretion and vegetation is not interrupted by premature human settlement. For that reason, in Bangladesh the Forest Department has the control in the newly reclaimed areas. Only after a period of a minimum of 10 years this is transferred to the Ministry of Land. However, in reality premature settlement often takes place, as soon as some sort of marginal existence can be achieved. In this context mangrove cutting should be regulated and social forestry should be implemented already in that early stage of development.

Once the period under the Forest Department is over, or once the area is heavily populated before that time, a decision has to be taken whether to protect the area and construct a polder, or to leave it unprotected. The following section (3.2) deals with the considerations that play a key role in that decision making process. If the outcome is not to go for empolderment, suitable infrastructure has to be developed for the unprotected area (3.3.1). In case the choice is made to build a polder, the required infrastructure has to be identified (3.3.2 to 3.3.6). With a polder, a number of issues are essential for the successful implementation and for its sustainability (3.5). Operation and maintenance are crucial for the sustainability of structures in polders and unprotected areas (3.6). The chapter closes with a few thoughts on future development of infrastructure in the central region of the coastal zone.

3.2 CONSIDERATIONS TO LEAVE CHAR UNPROTECTED OR DEVELOP A POLDER

3.2.1 Topography

The most important factor in taking the decision to empolder is the land level. There are a number of guidelines in this respect. It is generally understood that, in tide-dominated areas, land accretion slows down to almost zero when land levels reach about Mean High Water in the monsoon season (MHW_mons). At this level it is possible to start crop production. Therefore, MHW_mons can be taken as a sensible guideline for the start of empoldering.

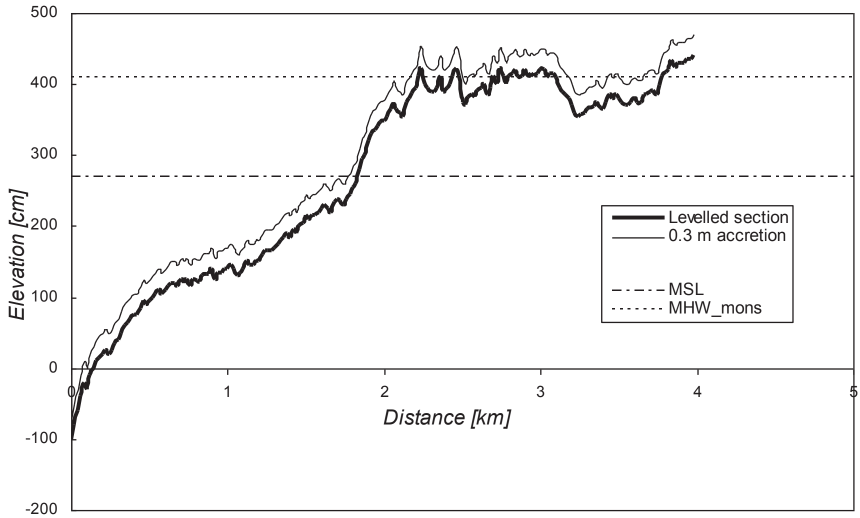
The required land level for empoldering is primarily related to water levels and not to PWD (benchmark of Public Works Department). For different areas different PWD heights will apply for empoldering because tidal water levels (such as Mean Sea Level, Mean High Water, Mean High Water Spring, etc.) vary across the area. Therefore, a rule of thumb like "empoldering should be started not before a land level of PWD + 3m" is dangerous because PWD + 3m can be above Mean High Water Spring in one place and well below this level in another place. On top of that there is a significant seasonal variation of the water level in the Lower Meghna Estuary with approximately 0.75 to 1.5 m higher sea levels in the monsoon.

The implication of the above is that tidal water levels should be known in the area of empoldering. This is achieved by collecting water level data and, if possible, by connecting the tidal gauges in the project area to a nearby established tidal station such as a BIWTA tidal gauge. By combining the local tidal observations and the long-term data of the nearest tidal station, the required tidal level such as MHW_mons can be assessed. It is also possible to carry out a harmonic analysis of local tidal measurements covering a period of for example 15 days to assess the relevant tidal constituents and the value of MHW_mons. Standard software is available for that purpose.

The determination of the precise and absolute elevation of an area of land as such is complicated. Land leveling data are subject to different variations and errors such as instrument-bound errors, human errors, variations in the location when surveys are repeated periodically, and spacing of the samples. Execution of leveling surveys, the related processing of data and controlling the above errors and variations require the skills of geodetic professionals. However, agencies responsible for empoldering land should be aware of the reliability of leveling data and possible variations, both in time and space. Ultimately the question they have to answer is when to start with empoldering.

As mentioned before, the monsoon Mean High Water level can be taken as the land level mark to start making a polder. Natural rising of land above this level will virtually not take place. However, the actual land profiles should be considered carefully. If there is only a small ridge at MHW_mons height along the outer fringe of a char with large depressions well below MHW_mons inside, empoldering would be premature. If scattered smaller depressions exist, covering — say, not more than 20% — of the area considered, then it is safe to construct a polder.

The picture below shows an example of two surveyed trajectories on the same place, with the second one after an additional 30 cm of uniformly distributed siltation. The Mean Sea Level (MSL) is assumed at +2.7m PWD and the monsoon Mean High Water tide at +4.1m PWD. If an embankment is constructed at a distance of 2.2 km on a land level of about +3.9m PWD, about 60% of the area landward of the embankment is still below MHW_mons. After another 30 cm of natural land accretion this is reduced to about 20 %, which may be considered as a sufficient small area of lower levels to take up empoldering.



In order to get a picture of the process of land growth as clear as possible monitoring should be carried out on a regular basis.

In conclusion, the PWD starting levels for creating a polder depend on the location because tidal levels vary across the areas. A better guideline for the start of empoldering is MHW_mons. Furthermore, careful consideration of the topography is required and it is recommended that at least 80% of the area to be empoldered has reached MHW_mons level.

3.2.2 Size

The size of the area to be empoldered is usually not free to choose. Rather, geographical and topographical conditions, and also administrative boundaries determine the area that can be empoldered. Nevertheless, there are some guidelines that can help to decide on the size and shape of a polder.

First of all, the delineation of the water catchment area should be considered. This forms the basic guideline for the determination of the size of the polder. In general, it is recommendable to include as a first option the whole catchment in the polder.

The economic feasibility of the polder depends on the balance between increased income on the one hand (improved conditions for agriculture) and costs of investment, maintenance and operation of the water infrastructure on the other hand. A favorable (=large) ratio of polder size vs. embankment length will be more economical. This consideration supports large polders with a high ratio between area and perimeter. At a later stage of development, when the economic value of the polder has increased significantly, it may be considered to compartmentalize the polder area to reduce the flood risk. Flooding of small polders will induce less damage but the flooding may be more violent because of the relative small basin and quick filling up in case of a breach of the primary embankment. In large polders the flood will spread out and attenuate because of the large distances along which the floodwater will propagate. Social disruption, loss of life, and other immaterial damage caused by more violent flooding may be another factor to support larger polders.

Another aspect to consider is fresh water supply (see also section 3.5). Smaller polders will partly need to rely on fresh water supply from outside because the storage capacity inside the polder is relatively small. The boundaries of small polders will likely intersect the relevant catchment areas and intake structures for fresh water are needed. On the contrary, large polders can accommodate larger storage areas and do not rely that much on fresh water supply from outside. Water management in large polders tends to be more complicated because i) the longer drainage (and possibly irrigation) distances and ii) because there is a larger variety in stakeholders in the same polder, putting different demands on the water system. This advocates for polders that are more uniform as to the interests of its inhabitants.

On the basis of the above considerations the initial areas to be empoldered should cover the whole catchment of the area, within the constraints brought about by land levels and geographical, topographical and administrative conditions. The area to be included in the polder should also be delineated on the basis of being a hydrological unit. In later stages of development with increased agricultural production compartmentalization of the polder (and reconsideration of desired safety levels) may become feasible.

3.2.3 Ecological Environment

A first identification of the ecological characteristics of the area to be empoldered should be carried out. This will be in terms of a description of the habitats, types, diversity and quantity and viability of the flora and fauna species in the area. Attention should be paid to the autonomous development of the ecosystem — the predicted development without the interference by the envisaged project. First, existing information and data should be collected. Next, field surveys are needed to complete this first initial inventory.

Based on this initial inventory the outline of a survey program can be drawn up under the EIA procedure (Environmental Impact Assessment). An EIA forms an obligatory part of a feasibility study (in addition, a Social Impact Assessment (SIA) is required as well). As a particular point of attention the migration potential of the ecosystem, that will virtually disappear due to the polder construction, needs to be evaluated. If, for example, a similar ecosystem is likely to develop in the coastal fringe adjacent to the new polder — due to further accretion and development of new chars — then the negative effects of the empoldering will be (partly) compensated by these new developments outside the polder.

3.2.4 Drainage of Adjacent Areas

When empoldering new areas, drainage of the adjacent land-side areas may become a problem. Existing drainage *khal*s may silt up due to the reduced tidal volumes they carry resulting in congestion in periods of rainfall. Therefore, proper drainage of adjacent agricultural lands should be an important design aspect of empoldering projects. If it is not possible to avoid impeding the drainage of nearby areas, it would be preferable to leave the area under consideration unprotected.

3.3 INFRASTRUCTURE FOR UNPROTECTED AREAS AND FOR POLDERS

3.3.1 Unprotected Areas

As explained in the previous paragraph, certain criteria apply in the decision-making process whether to make a polder of a newly accreted area or whether to leave it unprotected. If the unprotected area can still gain in land level by a continuation of flooding with sediment rich water, it is of course better not to protect it with embankments, so the floods still can come in. In future the decision can be taken to empolder the area. This happened, for instance, at the preparation of the fourth phase of CDSP, when Caring Char was left unprotected for a period of about seven years, because it was still too low. Another reason to refrain from making a polder would be that, though the land levels are high enough, the shape of the area would not make it economically attractive to do so (too small, too oblong). So, normally an unprotected area is vulnerable to tide, floods and cyclones throughout the year. There is usually little infrastructure as buildings and communication facilities. Drinking water is a severe problem, due to the absence of sufficient tube wells and the drying up of ponds in the winter season. Drainage channels are silted up due to the incoming sediment.

The infrastructure that has been built under CDSP in unprotected areas, starting in CDSP II, concentrated on basic needs of the settlers, as providing drinking water and enhancing their safety. Deep tube wells were installed and additional ponds, with a low dyke around them, were constructed. Roads were built, so people can flee to safety behind existing embankments of older areas. Cyclone shelters were established as well, for safety purposes and to make public space available for community meetings, schools etc. Sanitary latrines were distributed. Extension services on agriculture (especially on *aman* and *rabi* crops) and land settlement were initiated.

In unprotected areas, earthen roads suffer more from floods, especially during monsoon time, than roads in polders. Consequently, higher allocations for road repair have to be taken into account for unprotected areas. The same applies to re-excavation of drainage channels. During CDSP II, an experiment was done with protecting an area with a low embankment, which failed. The damage to the embankment due to floods was so great that the experiment was discontinued (see also section 3.3.3).

3.3.2 Polder Development: The Infrastructure

The main elements of infrastructure of a polder are the embankments (this paragraph and 3.3.3), the drainage system (3.3.4) and the intake/outfall structures (3.3.5).

The river or seaside boundary is exposed to tidal and flood water levels. In addition, wave attack may be a factor of importance. The latter has implications for the position of the embankment: waves will reduce when propagating over a shallow foreshore prior to break on the slopes of the embankments. This is a reason to apply a certain set-back, i.e., a distance between the shoreline and the embankment. The maximum wave height on the foreshore is depth-limited and will be of the order of 0.5 times the water depth. If data on local hydraulic conditions are available, a better estimate of the wave heights on the foreshore can be made. However, as a guideline a depth-limited wave height can be taken as the design wave height, i.e., the maximum unbroken wave height on the foreshore of the embankment.

In order to enhance the above wave reduction in the foreshore, mangrove forests should be maintained (sometimes called "herbal protection"). Especially in case of more moderate storms than design conditions, with lower water levels, the mangrove will be helpful in reducing erosion and scour at the toe of the embankment. Also the wave run-up and overtopping of the crest of the embankment will be reduced by the effect of mangrove plants. Therefore, mangroves fringing the polder should be maintained and extended as much as possible during the subsequent stages of development, especially because of the absence of any other shore protection works (see also Chapter 4). In case a shoreline has the natural tendency of erosion, mangrove will not stop this process. Mangrove will cause the waves to attenuate when propagating over the foreshore, however it will not halt erosive forces driven by large scale morpho-dynamics. It should be mentioned that closer to the embankment, other types of trees are more suitable as foreshore plantation.

A set-back of the embankment is also required if the shoreline at the riverside of the polder is retreating. This set-back should be based on the morphological dynamics of the adjacent river or coastal area, the lifetime of the embankment and the possibility of constructing a revetment on the outer slope and the toe of the embankment. The prediction of the future position of the shoreline should be based on a thorough analysis of historical positions of the shoreline. The Standard Design Manual of BWDB recommends adopting a set-back that allows for a 10-year period of erosion. Whatever set back is chosen, the cost of repair or partly reconstruction of the embankment should be accounted for if the retreating shoreline is assumed to reach the structure within the economic lifetime of the embankment.

Conclusively speaking, no fixed standard for this set-back can be put forward: the less agricultural benefits from a more landward position of the embankment should be balanced against the higher cost — investment and maintenance — of a more seaward location. In addition to such cost-benefit aspects the safety of the inhabitants of the polder should be considered.

3.3.3 Principal Dimensions of the Embankment

Sea-dykes and river embankments are essential elements of a polder design: they safeguard the inhabitants, their properties and the public infrastructure from flood disasters. The embankment should be sufficiently high to limit wave overtopping and prevent overflowing; and stable in order to withstand the forces (under design conditions), induced by wind, waves, currents and water levels. Guidelines for the design of flood embankments and sea dykes are found in the Design Manual of BWDB. A number of aspects are highlighted in the following.

Crest Level

In addition to the required set-back of the embankments the crest level and cross section can be indicated at this stage. This depends on the required level of safety for floods and storm surges. The BWDB Design Manual presents the following criteria for the design flood frequency (adopted in 2017):

- In case of construction of embankments beside major rivers: 1:200 years return period;
- In designing the top level of the embankment: a freeboard of 1.5 meters in case of the coastal region and 0.90 meters in other cases have to be added;
- In case of the coastal region an additional height of 0.30 meters or as high as deemed necessary have to be added to accommodate consequences of anticipated climate change.

Crest Width

The BWDB Standard Design Manual gives the following criteria:

- Minimum crest width is 2.50 m.;
- In case an inspection road is provided on the embankment, the minimum crest width is 4.30 m.;
- If the embankment is used as a road, the crest width is found from the relevant class of road plus 1.00 m shoulder on both sides.

Cross-Section

The side slopes are to be based on the soil mechanical stability of the embankment. BWDB distinguishes three kinds of embankments:

	r/s slope	c/s slope
Sea-facing	7/1	2/1
River-facing	3/1	2/1
Interior	2/1	2/1

In practice, the above values are being adopted without further detailed analysis and considerations. However, in a later design stage, the assumed values should be verified on the basis of soil-mechanical data and analysis. The values can vary slightly, dependent on the position of the dyke and the materials used for it.

Borrow Pits

Borrow pits for the construction of embankments are generally situated close to the embankment. At extreme water levels, the phreatic line inside the country-side of the embankment may have a downward tendency if the borrow pits, forming a lateral canal, are situated at the country side of the embankment. In addition, seepage water can be drained off through such a lateral channel. This will enhance the stability of the embankment. A borrow pit at the riverside may disturb wave action and cause undesired scour at the toe of the embankment. Therefore, if it is necessary to place a borrow pit at the riverside, the distance to the toe of the embankment should be at least about 40 m (estimated order of magnitude of the wave length under design conditions). An inside lateral canal may be used for fresh water storage, may serve fish culture and could be used as a collector drain. Although in coastal areas a borrow pit at the sea side will be silted up, mitigating the disadvantages, it is, all in all, preferable to situate borrow pits at the countryside of the embankment.

Low Embankments

Low-crested, submersible embankments are meant to prevent pre-monsoon flooding but to allow for monsoon flooding. The frequency of flooding is determined by the crest level. However, it should always be realized that overtopping may induce severe erosion of the crest and leeward slope of the embankment. Therefore, more severe requirements need to be put on these parts of the structure in order to prevent failure and collapse. A low-crest embankment will induce an increase in agricultural benefits compared to the unprotected situation because of the reduced flood frequency.

Low-crest embankments, if applied, should not be constructed on land that has not yet reached the required elevation for empoldering. Otherwise, the accretion of the protected area is slowed down and the desired levels for "normal" empoldering will not be reached anymore, that is at about monsoon mean high tide level (MHW_mons). This means that in the long run, when the low-crest embankment would be upgraded to the normal standard, the protected area will be lower compared to the situation with a standard embankment. This is an undesired situation in view of the long-term soil salinity and monsoon drainage congestion. Although it has appeared that the peak values of the soil salinity at the end of the dry season do not tend to reduce, lower land is always more unfavorable than higher land. Moreover, when a low-crest embankment is flooded, salt water will be contained for a longer period of time in the polder, compared to the original situation without embankment, contributing to soil salinity.

Frequent overtopping and overflowing will put high demands on the quality of the low-crest embankment. This refers especially to the quality of the top layers on the crest (should be well compacted and impermeable to prevent infiltration) and inner slope that should not be steeper than about 1/3 and actually be well covered by vegetation to increase erosion resistance. The application of low-crest embankments may raise false perceptions of safety for flooding, which are not realistic. This puts ethical questions to the application of low-crest embankments. In practice, it will be hard to prevent people from settling on the land protected by a low-crest embankment.

In conclusion, a low-crest embankment is, in general, not recommended in coastal areas because (i) soil salinity will be higher, (ii) frequent overtopping and overflowing of the crest of the embankment endangers the stability of the crest and inner slope, and (iii) false perceptions of safety for flooding may prevail.

3.3.4 Drainage System

For the conceptual design of the system of drainage channels, the pattern of natural arterial drainage should be mapped. Drainage requirements for the new polder are based on design criteria such as suggested and practiced by BWDB. In general, a 10-days rainfall period with a return period of 10 years is taken for the analysis of required drainage capacity. The revised BWDB design criteria of 2017 stipulate that 15% should be added to the design rainfall to account for future climate change.

Drainage of the new polder lands should be considered carefully. The natural drainage system should be taken as the basis because it reflects the natural topography and land slopes. An important consideration is the (possible) need and planning of drainage regulator sluices. The various functions of such structures are mentioned in 3.3.5.

An open drainage system, without regulator sluices, should be considered as well. Careful consideration should be made regarding the risks and damages due to the intrusion of saline water, sediments and also due to entering of river floods or storm surges. Because of the propagation of tidal water through the open drainage system the outfall channel will be less subject to siltation. In case a regulator sluice is constructed, the outfall channel at the river side of the sluice is mostly subject to rapid siltation in the dry season. Drainage conditions of the new polder should not only be evaluated for the situation upon completion of the polder, but also for future circumstances.

Very often natural accretion of coastal lands will continue outside the polder, which may cause drainage distances to lengthen and, consequently, drainage capacities to reduce. In that case intervention measures to rehabilitate the drainage function may be required, the cost of which is to be included in the overall economic evaluation.

3.3.5 Intake and Outfall Structures

Intake and outfall structures are needed to control the water system of the polder. In the prefeasibility stage it is indicated where these structures can be located (conceptual design). In a later stage the design will be completed, normally first on feasibility level and next on detailed level. In coastal areas, the sluices are usually only used as outfall structures. Intake of water for irrigation or fishery purposes, seldom occurs.

Intake structures are needed if the empoldered area needs fresh water supply from areas outside the polder and if outside drainage water will be conveyed through the polder to its receiving water body. Normally an intake structure will facilitate a controlled inflow of water into the polder. The intake structure needs a closing device if it is situated in a flood protection embankment.

A drainage outfall structure has different functions:

- It should regulate drainage of excess water from the polder.
- It prevents undesired intrusion of sediments and saline water from outside into the polder.

- It is mostly situated in a main flood embankment or sea dyke and should therefore be able to withstand extreme water levels and wave attacks from outside the polder.
- It serves as a water retaining device in the dry season, enabling the storage of fresh water.
- It may enhance possible navigation in the new polder, because of the above water retention function.

These aspects should be taken into account when considering the water system of the area and the need for drainage outfall structures.

Siltation is a well-known problem in drainage outfalls, mostly occurring in the dry season when the gates are closed. However, rates of siltation vary strongly and depend on the location. The construction of temporary cross-bunds in drainage channels to prevent siltation in the dry season is common practice across the area and discussed in many reports.

Sedimentation in drainage outfall channels is caused by the tide carrying silt-loaded water into the channel. Silt bars develop, the channel profile narrows and quite often sediment blocks consequently the flap gates. The rate of sedimentation varies from place to place and tends to increase with increasing length of the outfall channel. It is recommended to regularly monitor the condition of the outfall channel, not necessarily by costly survey work, but rather by field inspection and here and there checking of the channel cross sections. During the monsoon the drainage outfall channel is flushed by the excess drainage water from the polder, which may cause removal of part or all sediments deposited during the dry season. This occurs if the flushing capacity is sufficient.

To avoid such sedimentation of the outfall channels and blocking of flap gates in long outfalls (longer than about 500 m) it is recommended to construct an earthen cross-dam at the downstream end of the outfall channel. The cross-dam should be constructed at the beginning of the dry season but not before sedimentation levels downstream of the sluice have reached a level between the floor of the stilling basin and the invert level of the vents. This is required to reduce further scouring of the bed of the outfall channel later on in the beginning of the monsoon, when high discharges of excess rainfall run-off from the polder may coincide with low tide in the outfall channel. Before the first rains are about to start the cross-dams should have been removed again.

To avoid blocking of flap gates by sediment deposition in a short outfall (shorter than about 500 m) it is recommended to remove the silt and mud hampering and blocking the flap gates by water jetting, deploying portable irrigation pumps with a capacity of about 100 l/s. A good alternative is to use canal maintenance groups (organized by WMOs) to undertake the clearing of the channel.

3.3.6 Hydraulic and Morphological Data

There is a vast amount of knowledge and data about the hydraulic and morphological conditions of the Lower Meghna Estuary. For the preliminary design of empoldering projects tidal water levels, extreme storm surge levels, future changes of water level, wind and wave conditions and future morphological changes are the most important. These quantities form the seaward boundary conditions of the polder to be developed and knowledge thereof is needed for the alignment and the design of embankments and other flood control structures.

Tidal water level data are also required for the design of the drainage system because of the influence on the discharge capacity of drainage outlet structures and channels. In addition, it is important to collect data on salinity. Surface water salinity is important for possible intake of water into the polder. Groundwater and soil salinity are important to determine the agricultural production potentials.

3.4 ISSUES RELATED TO POLDER DEVELOPMENT

3.4.1 Fresh Water Supply

Salinity of the waters outside the polders varies with the seasons: maximum values are reached in the pre-monsoon (April, May) and vary between 20 and 30 dS/m (12-19 ppt) which is more or less equal to sea water salinity. Over time, levels depend on the location of the area. For instance, it seems that at Char Bhatir Tek such levels are reached earlier than at Char Baggar Dona and Char Majid. The minimum levels are observed in the period October-January. This is understandable because the major upland fresh water flow passes the receiving waters of this polder. The value of 2 dS/m, which is critical for irrigation purpose is mostly reached in October or November (see also Chapter 7). However, sometimes this happens earlier (Char Bhatir Tek, September), or later (Char Baggar Dona, December). Inside the polder the salinity of the water in the *khal* is close to zero in the monsoon and increases in the dry season to measured values of 10 to 30 dS/m in Char Majid and 10 dS/m in Char Baggar Dona and Char Bhatir Tek. It is noted that by that time the *khal*s contain little water. Therefore, evaporation certainly contributes to the measured high rates of salinity.

Groundwater salinity was measured in three piezometric tubes (mostly 5, 3 and 1.5 m in length) at some distance from the drainage sluices: Char Majid about 1.5 km, Char Baggar Dona about 2.5 km and Char Bhatir Tek about 3 km. Groundwater salinity levels start to rise in the period October — January. Peak levels are of the order of 2 dS/m (Char Baggar Dona 2 to 3; Char Bhatir Tek below 2). In Char Majid some more variation occurs in peak levels: the 3 m piezometric tube shows peak values of about 4 dS/m, reached in May, the 2 m long tube peak values of 6 dS/m and the shortest 1.5 m tube values from 5 to over 10 dS/m across the 4 years monitoring period.

When planning salinity measurements of the waters outside regulator sluices, care should be taken of the location where samples of the tidal water are taken. This is not always near the sluice. With a cross dam in the drainage outfall channel, the enclosed water is subject to evaporation, resulting in continually increasing levels of salinity. This explains most likely unrealistic high values of the salinity outside the sluices.

Potential sources of fresh water should be analyzed. Information and data on ground water resources should be collected from adjacent and comparative areas, in addition to data from the envisaged polder area itself. In general, large scale groundwater extraction from aquifers within 200 m from the ground level does not seem feasible, because of the small number of potential locations and the quality of the groundwater. This has appeared from earlier studies. The installation of deep tube wells may be possible, although the economic feasibility has not been assessed yet. Environmental risks (subsidence, saline water intrusion) are to be incorporated in such an assessment.

It is important to determine whether irrigation water will be needed to enter the future polder via intake structures. In coastal areas it may be considered to take in tidal water in the post-monsoon period, when there is already some scarcity of fresh water. This could be done in October at the latest. Potential storage of fresh water in the polder may be enhanced by enlarging the *khal*s. Fresh water ponds are wide-spread in the coastal communities. Analysis of the water use from such ponds indicates unaccounted water losses, apart from evaporation, possibly due to leakage and seepage to the subsoil. The cause of these losses should therefore be investigated and possible mitigating measures like sealing the bottom of ponds should be evaluated.

Manual irrigation and hand-operated tube wells generally contribute significantly to homestead production of, for example, chilly and potatoes. Salinity surveys are needed to judge the suitability of such potential water sources. In order to prevent resalinization due to evaporation such irrigation should be practiced with sufficient quantities of water at once and not more frequently with small additional amounts, a fact the farmers are well aware of.

3.4.2 Decrease of Land Levels

In the course of time, land levels in empoldered areas will drop with respect to sea-level because of subsidence, settlement of upper layers and climate induced sea-level rise. The natural delta system responds to these phenomena by increasing rates of siltation and land accretion. However, empoldered areas are isolated from such accretion mechanisms and will lag behind.

Annual subsidence rates are estimated at 2 to 3 mm in the northern part of the Meghna Estuary and 4 to 6 mm in the southern part. One should account for subsidence of the above rate when considering the lifetime of the polder. For example, when considering a period of 100 years, land elevation will be reduced by about 0.5 m due to subsidence in the southern parts of the delta. In addition, climate-induced sea-level rise is a factor as well. The Bangladesh Delta Plan 2100 mentions an overall trend of sea-level rise in the coastal zone of 6-20 mm a year, dependent on the location. Adding geological subsidence, a rate of 1.5 m or more per century is not unrealistic as scenario for the sea-level rise relative to empoldered areas.

3.4.3 Geo-Hydrological and Soil Conditions

Soil salinity is a most important aspect as it poses an important agricultural constraint and it is important that soil salinity levels reduce (see also Chapter 7). Although desalinization of the soil will develop after empoldering, it is not possible to precisely predict the rate. Roughly speaking the development of soil salinity will depend on three mechanisms: i) deep drainage of saline ground water to the drainage basin, ii) leaching of the upper soil due to rainfall, and iii) resalinization due to capillary rise in the upper soil (stimulated by evaporation and evapo-transpiration) and flooding by saline water.

Deep natural groundwater drainage has reportedly been overestimated in the past. The deep drainage flow may even be reversed in the dry season if the groundwater table is below the drainage base. Shallow groundwater drainage is also not a factor of importance because of the very scarce drainage facilities. Surface drainage is limited to periods of excessive rainfall and most likely not important for salt removal. However, leaching of topsoils in char areas contributes substantially to desalination. The downward flux of fresh monsoon rainwater, and upward capillary rise prevailing in the dry season, causes a cyclic, seasonal up and down movement of the shallow ground water table. All in all, the main factors for slow or insufficient desalinization are a limited gradient of ground water to the shallow drainage base and high evaporation and strong capillary rise, causing a drop in the groundwater level and possibly a reversal of the deep drainage.

Therefore, first of all it is recommended to take up empoldering with land levels as high as possible (see section 3.2.1) and secondly, working the upper soils and ploughing as soon as possible in the post-monsoon will isolate the top soil from the layers beneath and forming a blockade against capillary rise in the subsequent dry period. It is often observed that the farmers themselves do adopt the best practice of farming to reduce resalinization to the extent possible, either deliberately or intuitively.

It is recommended to collect existing information and to map the geo-hydrological and soil conditions in order to analyze the desalinization potential of the envisaged areas. This can be done by comparative analysis, using data on desalinization of similar areas. The CDSP polders start to show a stabilization of the soil salinity. Since the measurements of 1996 no significant overall reduction of soil salinity seems to appear and the pattern of strongly increasing salinity levels during the dry season and lowered values in the monsoon do persist throughout the various polders albeit to a different extent. Char Baggar Dona shows a more mild regime compared to Char Majid and Char Bhatir Tek. However, linear trend lines through the various data series show in most cases a small decline. In Chapter 7, attention is given to soil salinity and agriculture.

3.4.4 Socio-Economic Issues

A description and analysis of the socio-economic conditions, the type and degree of social organization (see Chapter 9), the autonomous development (without project) and the possible changes due to the envisaged empoldering should be started already at an early stage of polder development. This should be based on existing information, documents and field surveys.

Because the development of a polder requires land and space for infrastructure, land acquisition is an important issue in polder development. It is recommended to identify already in the early stage the possibilities of land acquisition and of sufficient compensation in case land dispossession is required for the realization of the required infrastructure.

In addition to the above some other key-issues are mentioned here:

- Conflicting claims on land property (see also Chapter 8);
- Possible livelihood of inhabitants who happen to live at the river side of the embankments (for example social forestry, the construction of mounds to live on);
- Conflicting interests from land use, i.e., shrimp farming vs. agriculture;
- Reduction or even elimination of natural fresh water fishing activities and options for alternative economic activities (culture fishery in ponds);
- Type and level of organisation in water management (see Chapter 9); and operation and maintenance of the water system, the subject of the next section.

3.5 OPERATION AND MAINTENANCE

3.5.1 Concept of Operation and Maintenance

Definition

The concept of operation and maintenance (O&M) contains all those activities aimed at ensuring that infrastructure is in a good condition, so it serves and can continue to serve the purpose of the object in question. The infrastructure is subject to wear and tear by natural phenomena as weather, storm surges, erosion etc. and by human activities and actions of animals, for instance cattle movement. The status of water management related structures (embankments, sluices, drainage channels) is directly related to the safety of people, livestock, crops and goods. For agriculture, proper sealed sluices are essential for the growth of especially *rabi* and *aus* crops, as is explained in Chapter 7. Well maintained drainage *khal*s support a healthy *aman* crop. Internal infrastructure as roads and bridges have great economic benefits, while cyclone shelters, of course, serve the safety of the settlers. The importance of O&M can therefore not be overestimated.

The following aspects are to be ensured with respect to operation and maintenance: What types of maintenance can be distinguished (see below)? How are O&M activities organized (see section 3.5.2.)? What does it cost and how it can be paid (see section 3.5.3)?

The following types of maintenance can be distinguished: preventive/routine maintenance; periodic maintenance; emergency maintenance; and rehabilitation.

Preventive Maintenance

Preventive maintenance is the maintenance which is done on a continuous and regular basis to prevent deterioration. Examples of preventive maintenance activities are: repair of small breaches in embankments and earthen roads; repair of holes made by rodents; clearing of shrubs and bushes on embankment and road slopes; repair of turfing on slopes; removal of cross dams made by farmers in secondary drainage *khal*s; removal of debris in front of sluice gates; greasing and painting of sluice gates.

Periodic Maintenance

This is the maintenance which is done at a certain time interval when maintenance becomes mandatory to save the infrastructure. The interval is defined as maintenance cycle. In most cases, this cycle is 3-4 years. Examples are: re-sectioning of embankments, earthen roads etc.; repair of breaches in embankments; canal bank protection work; carpeting and sealing of paved roads; re-excavation of main–, secondary– and outfall channels; silt removal from both sides of the sluice (in the active delta especially from the river side); any mechanical– or civil works related to sluices, including gate replacement and structural repair of the apron; major repair of bridges and culverts, including road approaches and bank protection work; replacement of broken pipes and collars of pipe culverts.

Emergency Maintenance

This type of maintenance cannot be predicted. It is repair of heavy damage caused by unforeseen events as natural hazards such as sudden cyclones, storm surges, tidal boors or heavy torrential rain. It can be expected that in future the need for this type of maintenance will occur more often due to erratic weather patterns as a consequence of climate change.

Rehabilitation

Rehabilitation is a major repair or replacement of the infrastructure. This happens when normal repair or renovation is not sufficient any more to get the infrastructure returned to its original function. In such situations a major intervention is required.

Special Requirements in Coastal Areas

There is obviously more wear and tear of infrastructure in the coastal zone than in more inland located areas. A considerable problem is formed by salinity. It affects materials of sluices, bridges and buildings. More preventive and a higher frequency of periodic maintenance is therefore needed. Erosion can cause tremendous damage to embankments and can endanger sluices. Accretion lengthens the drainage path and sedimentation causes outfall channels on the riverside of sluices to lose capacity. In many places along the coast, good earth for embankment construction is not available. The same applies to good quality material for turfing of the embankment slopes. Holes in the embankment caused by rats do happen more often in coastal areas. Because many of the structures are in remote places, organizing and implementing O&M is much more difficult than elsewhere.

3.5.2 Organization of O&M

Division of Responsibilities

The main implementing agencies for construction and O&M of infrastructure are BWDB, LGED and DPHE. Other parties involved in O&M are the local government and community-based organizations, of which the Water Management Organizations are the most relevant ones. A very roughly sketched description of their responsibilities is: BWDB — Bangladesh Water Development Board whose mandate is to plan, implement and maintain projects with areas of 5,000 ha area or more; LGED — Local Government Engineering Department entrusted with the construction of roads, structures, bridges etc. and with the planning, implementation and maintenance of water resources projects between 1,000 ha and 5,000 ha; DPHE — Directorate of Public Health Engineering entrusted with the task of ensuring good potable drinking water, health and sanitation facilities for the people; LGIs — Local Government Institutions entrusted with the implementation of small projects, village road, culverts, small canals etc. and water resource projects up to 1,000 ha.

WMOs — Water Management Organization entrusted with the task of petty maintenance of sluices and other petty repair of roads, clearage of jungle etc.

The Guidelines for Participatory Water Management, issued by the Ministry of Water Resources, give the following detailed division of tasks:

Table 3.1 O&M Responsibilities According to the Guidelines for Participatory Water Management

Implementing Agency (First Party)	LGI (Second Party)	WMG/WMA/WMF (Third Party)
Operation responsibilities		
• Operation of main hydraulic structures in discussion with Second and Third Party. • Observe and inspect operational procedure of medium hydraulic structures with Second and Third Party and provide technical advice for proper operation.	• Take part in the operation of main structures in discussion with First and Third Party. • Observe and inspect operational procedure, process and necessity for operation of all medium and minor hydraulic structures and advice for proper operation to Third Party.	• Take part in the operation of main hydraulic structures with First and Second Party. • Operation of all medium and minor structures as per requirement of stake-holders. • Develop operation plan as per requirement of stakeholders.
Maintenance responsibilities		
• Routine/annual maintenance of the main hydraulic structures. • Periodic maintenance (after 3 to 4 years) of the main embankment, main and secondary channels • Major flood emergency work • Repair of the major damage by floods. • Re-construction and re-habilitation of infrastructures. • Major erosion protection work.	• Routine/annual repair and maintenance of the medium hydraulic structures including replacement of fall-boards. • Routine/annual repair and maintenance of main embankment, secondary and tertiary channels. • Participation in major flood emergency work undertaken by First Party. • Repair of minor flood damage work. • Medium erosion protection Work. • Painting of gates of medium structures.	• Preventive maintenance of the medium and minor hydraulic structures, bridges, culverts etc. • Preventive maintenance of the main embankment and secondary embankment. • Routine/annual maintenance (desilting) of field channels, drains etc. • Clearing weeds, obstacles from secondary and tertiary channels, drains etc. • Regular greasing of gates. • Annual painting and minor repair of minor gates and replacement of fall board.

The above table can be simplified as follows:

Name of structure	Type of maintenance	Responsibility
Embankment, sluices	Periodic	BWDB
Canal and borrow pit	Preventive	WMO and LGI (UP)
Feeder road, rural road	Periodic	LGED
	Preventive	LGI (UP) and WMO
Bridges, culverts	Periodic	LGED
	Preventive	WMO and LGI (UP)

WMGs directly execute some of the maintenance works awarded to them by the agencies. Routine and petty maintenance works are being done by the WMGs themselves from their own fund. WMGs keep constant contact with the agencies and pressure them to do the necessary repairs in time.

Maintenance Plans

At the end of CDSP-I, in 2000, a Maintenance Plan was produced for each of the three polders (Char Majid, Char Baggar Dona-I and Char Bhatir Tek). These plans were jointly prepared by BWDB, LGED, Union Parishads and WMOs. The WMOs prepared the first draft based on discussions in the monthly and special meetings. Then they placed it before the agencies and the UPs. Ultimately it was finalized in a meeting where all parties were present, chaired by a representative of the BWDB. The plan was signed by all four parties. The role and responsibilities of each party were identified in the plans, along with the source of financing. But the execution deviated slightly from the plan. Factors that played a role were: non availability of funds from UP side; shortage of funds from the implementing agencies; lack of coordination and linkages among the parties involved in execution of the plan. This system was changed in later years, largely because of two reasons. The shortage of available funds resulted in disappointment among the farmers in the WMOs. At the same time, the decision was taken by BWDB to implement maintenance works that were not too complicated through the WMOs themselves, and not through contractors. Instead of the four party Maintenance Plans, a series of 15 area-wise bilateral agreements emerged between BWDB and the respective WMOs. These agreements covered all CDSP I and II areas: three agreements in Bamni with Water Management Associations (an association of Water Management Groups); two in South Hatiya with the WMA; one in the Gangchill area with the WMA. Nine agreements were signed between the BWDB and WMGs of Char Majid, Char Bagar Dona I, Char Bagar Dona II, Nabagram, Kolmi, Zillar, Montaj, Karim and Gopal.

For Boyer Char (CDSP III), agreements were signed with both BWDB and LGED. In CDSP IV each year O&M agreements were entered into between BWDB and WMGs.

3.5.3 Costs

The Bangladesh Water Development Board

Since its start in 1959, BWDB has implemented hundreds of projects of a wide variety of types. To name a few: flood control and drainage schemes, similar schemes plus irrigation, projects with a combination of only drainage and irrigation, or just irrigation, and coastal embankment activities, including the construction of polders.

The total value of the investments of all BWDB schemes combined in the 50 years since 1959 is estimated to be Taka 20,000 crore. As a rule of thumb, the O&M costs amount to 3% of the investment costs. This means that the total yearly requirement for O&M of BWDB infrastructure is Taka 600 crore. However, in practice this level of finance was never available in the O&M budget of BWDB. The table below shows that over the last years around 45 to 50% was allocated, with slightly less actual expenditures. as a result proper maintenance is hampered to the detriment of the quality of the infrastructure. And this will subsequently have a negative effect on the livelihoods of people.

Table 3.2 gives an idea about the O&M funds available for BWDB and the corresponding expenditure during the period 2003-04 to 2009-10 (source: BWDB).

Table 3.2 Year Wise O&M Budget and Expenditure of BWDB (in Crore Taka)

2003-04		2004-05		2005-06		2006-07		2007-08		2008-09		2009-10	
Alloc.	Exp.	Alloc.	Exp.	Alloc.	Exp.	Alloc.	Exp.	Alloc.	Exp.	Alloc.	Exp.	Alloc.	Exp.
100.00	95.66	125.90	125.4	150.00	135.8	150.00	144.93	281.50	281.46	346.00	338.38	402.00	401.98

The table shows that expenditures are invariably lower than the budget allocation. This is often due to the non-availability of cash funds, delays in tendering and adverse weather conditions. Lack of field staff and more attention for new projects are certainly reasons as well. But the allocations themselves are far less than the actual requirements and have even declined in the years after 2009-10 according to BDP2100: 305.1 crore Taka in 2010-11, 317.8 crore Taka in 2011-2012, 367.8 crore Taka in 2012-13, 355 crore Taka in 2013-2014, 371 crore Taka in 2014-2015 and 372.7 crore Taka in 2015-16. The actual demand, given the backlog in maintenance accumulated over many years, is estimated to be around 10 times the availability.

In principle, under normal conditions, periodic maintenance is done every three years in the lifetime of the infrastructure of the completed polders and projects of BWDB. With the fund situation as it is, this period will in reality obviously be longer. As explained, there are arguments that periodic maintenance in coastal areas should be done with a higher frequency than in other parts of the country.

CDSP

The combined investment costs (all agencies) in CDSP-I, II and III for infrastructural works directly related to the construction of polders and improvement of unprotected areas along the coastline are Tk. 1.592 billion (Tk. 266 million, Tk. 612 million and Tk. 714 million respectively; infrastructure development in CDSP IV is still ongoing). Then, taking the 3% rule for maintenance costs, the annual allocation for maintenance fund in CDSP-I, II and III should be Tk. 47.76 million. If we take the three CDSP I polders as an example, annual maintenance expenditures would be Tk. 7.98 million. However, the actual expenditures for the eight year period between 2002 and 2010 for CDSP I works was only Tk. 20.5 million, or on average Tk. 2.56 million a year. This is about one third of the amount if the 3% rule is followed. The fact that it was still relatively new infrastructure, explains a part of the deviation from the standard norm for maintenance. But shortage of funds certainly was a factor too.

The source of the actual expenditures for maintenance for CDSP I for the 2002-2010 period was divided as follows: BWDB Tk. 8,825,400 (43%); LGED Tk. 9,120,780 (44.5 %); DPHE Tk. 1,700,000 (8%); WMOs: Tk. 598,565 (3%); UP Tk. 267,350 (1.5 %). The costs covered by the Government agencies were booked against a budget line in the project budget of CDSP. Those were Government funds, not donor funds, but ultimately from the Government development budget, not its revenue budget. The same applies for O&M costs in CDSP II and III as well.

Costs in Relation with Benefits

The three polders of CDSP-I cover an area of approximately 5,000 ha. Actual O&M expenditures per year were Tk. 2.56 million, or Tk. 512 per hectare. Taking the 3% rule, O&M for CDSP-I areas would be Tk. 1,595 per hectare. In comparison, the estimated annual per hectare costs for preventive and periodic maintenance in the nine polders of the Integrated Planning for Sustainable Water Management (IPSWAM) program are Tk. 833.

For Boyer Char (CDSP III), an area of approximately 6,000 ha., the 3% rule of thumb would mean annual O&M costs of Tk. 3,570 per hectare. This is much higher than CDSP-I due to inflation and the fact that Boyer Char required more embankments and sluices. However, the net income per hectare after establishment of the polder, might be in the order of at least Tk. 80,000. In case of Boyer Char, annual O&M costs per hectare for all infrastructure in the polder (embankments, sluices, drainage channels, roads, bridges, cyclone shelters, tube wells) based on the 3% rule, would be around 4.5% of the revenue per hectare.

3.5.4 O&M in Future

In future coastal development programs, O&M of infrastructure should have a much higher priority than hitherto was the case. In the investment budgets, sufficient funds should be set aside for O&M during the project period. For maintenance costs after the project period, provisions should be made in the O&M revenue budget of the concerned agency.

The practice of CDSP to prepare maintenance plans, translated into agreements between the WMOs and the state agencies, is worthwhile duplicating in future programs.

With a view on the special circumstances in the coastal zone, a separate O&M cell for coastal areas and a separate O&M budget for the area may be arranged for pivotal agencies like BWDB and LGED.

Throughout BDP2100, attention is given to O&M. Neglect of O&M requirements has led to sub-optimal functioning of water resources schemes, be it related to flood control, irrigation or water supply. Overall need for O&M is estimated to be around 0.5% of GDP, while current levels are less than 0.1%. Apart from much more funding from the government side (under the recurrent budget), capacity building and an integrated approach, based on improved cooperation between institutions, are seen as ways forward. Gradual shift towards lower levels of government and communities form an essential part of the policy promoted in the plan. O&M related activities and expenditures should be included in monitoring systems of coastal projects.

3.6 CONCLUSIONS

Following conclusions are drawn, categorized in decision of empoldering, eco-engineering and ecology, design, drainage, water supply, and finally, operation, maintenance and monitoring.

Decision on Area of Empoldering/land Acquisition

- The initial areas to be empoldered should cover the whole catchment of the area. In later stages of development compartmentalisation of the polder (and reconsideration of desired safety levels) may become feasible. If scattered smaller depressions exist, covering — say, not more than 20% — of the area considered, then empoldering may be taken up.
- Establishing and maintaining one common baseline set of data on which the project is based.

- In the early stage of development, the possibilities of land acquisition should be identified as well as the needs of adequate compensation in case land dispossession is required for the realisation of the required infrastructure.
- Mean High Water in monsoon time (MHW_mons) can be taken as a sensible guideline for the start of empoldering.
- A low-crest embankment is, in general, not recommended in coastal areas because i) soil salinity will be higher, ii) frequent overtopping and overflowing of the crest of the embankment endangers the stability of the crest and inner slope, and iii) false perceptions of safety for flooding may prevail.
- A rate of 1.5 m or more per century can be adopted as scenario for the sea-level rise relative to empoldered areas.

Eco-Engineering and Ecology

- Regulation of mangrove cutting and social forestry is to be stimulated in that early stages of development.
- If no mangrove exists it should be planted, on the foreshore of the embankment. In the case that accretion of new land will continue seaward of the polder, an initial mangrove fringe of about 200 to 500 m is considered to be sufficient. At a stable coast a width of 500 m at minimum is recommended.
- The migration potential of the ecosystem that will virtually disappear due to the polder construction needs to be evaluated.

Design

- Guidelines for the design of flood embankments and sea dykes are found in the Design Manual of BWDB. Two aspects are mentioned in addition to it: fully document new designs and make the design process transparent for later references; and mention explicitly the required maintenance in the design document.
- It is recommended to adopt a value of about 5 times the wave length for the length of the foreshore.
- A depth-limited wave height can be taken as the design wave height, i.e., the maximum unbroken wave height on the foreshore of the embankment (see the above example).
- It is preferable to situate borrow pits at the countryside of the embankment.

Drainage

- For the conceptual design of the drainage system the pattern of natural arterial drainage should be mapped. an important consideration is the (possible) need and planning of drainage regulator sluices. Furthermore, drainage conditions of the new polder should not only be evaluated for the situation upon completion of the polder, but also for future circumstances.

- The possibility of taking in fresh water through drainage sluices should be addressed in the feasibility study.
- A temporary cross dam at the end of a drainage *khal* can prevent undesired siltation. Proper attention should be paid to the timing of such a dam.

Water Supply

- Ponds are an important fresh water source. In order to analyse their performance data should be available regarding the subsoil conditions. Also water retention in the system of *khal*s and channels is an important issue to be dealt with in the feasibility study.
- Deep groundwater extraction should not be planned as a substantial activity.
- Rain water harvesting should be stimulated for domestic fresh water use.

Operation, Maintenance and Monitoring

- The control of the sluices shall be defined in the operational water management rules that are, in turn, the outcome of an integrated water management plan or schedule of the relevant polders under auspices of the relevant Water Management Committee. Most importantly the WMG decides on the (target) water levels throughout the different seasons.
- Substantial attention should be paid to the risks (and costs) due to lack of maintenance. Maintenance budgets of implementing agencies should be increased. Area wise Maintenance Plans should be drawn up and agreed upon by state agencies, local government and WMOs.
- The interior drainage system should be well-maintained in order not to jeopardize the drainage capacity and not to cause drainage congestion. The maintenance should be based on the WMG-journals of the flood and drainage situation of the respective areas.
- It is recommended to monitor key parameters related to the performance of the drainage sluice. Sluice operation can be improved by relating the factual data on sluice operation to the observed pattern of flooding and drainage in the fields, chronicled in the drainage journal.
- Monitoring/mapping of agricultural activities and soil conditions should include the physical water system, the water infrastructure, water management practice, and mapping of zones of agricultural potential.

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Chapter 4

Forestry Development in Coastal Areas

Ishtiaq Uddin Ahmad

4.1 FORESTRY POLICIES AND INVOLVED INSTITUTIONS

Protection of the country against natural disasters is the main objective of the national Environment Policy (1992), which focuses on the maintenance of the ecological balance and of sustainable development. The policy encompasses important sectors like coastal forest, wildlife, biodiversity and the marine environment, as well as ecologically critical zones.

The National Forest Policy (1994) emphasizes the establishment of plantations on all newly accreted lands in the coastal area. While formulating the policy, special consideration was offered to the roles of the forestry sector in the overall socio-economic development of the country and to environment. Full attention was given to the Agenda of the Earth Summit 1992. The National Forest Policy, for the first time, elaborated the participatory forestry concept in clear terms. This has opened up the avenue for cooperation between NGOs and state agencies in the area of social forestry. A target was set to develop 20% forest cover by implementing massive plantation programs, in order to meet the demand of present and future generations. This target also aimed to ensure a greater contribution of the forestry sector to economic development and poverty reduction. To make the policy directives operational, the Forestry Sector Master Plan (1995-2015) with an investment target of Taka 80,000 million for the period of 1995-2015 was formulated and approved. Accordingly, different programs have been undertaken. Amongst other measures, the Master Plan provides guidelines to take up massive people oriented plantation programs both on government– and privately owned land.

Regarding coastal forest, the Coastal Zone Policy (2005) has a similar commitment. It generally emphasizes sustainable development in the coastal region and directly supports the establishment of coastal plantations, conservation of existing coastal forests and preservation of coastal habitats. The policy specifically mentions the need of forestation of newly accreted chars and encourages social forestry.

Social forestry programs, with people's participation received momentum in the country by amending the Forest Act of 1927 in 1990 and in 2000. The amendments of the Forest Act of 1927 support and encourage social forestry/participatory forestry activities in the country. Specific Social Forestry Rules were enacted in 2004. Recently, in January 2010, the Government of Bangladesh amended the Social Forestry Rules of 2004 by incorporating some sections and sub sections to invest in forest land and government land (*khas* land) for social forestry purposes. The updated Forest Act and Social Forestry Rules provide legal support to participatory forestry. It is expected that the recent amendments in the Social Forestry Rules will provide a stimulus to the social forestry movement in the country.

The Bangladesh Climate Change Strategy and Action Plan 2009 includes a separate program on afforestation and reforestation under the theme "Mitigation and Low Carbon Development". It supports new coastal afforestation programs, taking into account the expected rise in salinity levels due to sea level rise. It promotes afforestation to protect settlements against erosion due to wave action, as well as new social forestry schemes.

In June 2019 the Ministry of Environment, Forest and Climate Change published the strategy on reducing emissions from deforestation and forest degradation (known as the United Nations REDD program), combined with conservation of forest carbon stocks and sustainable forest management (known as REDD+). The country's vision for REDD+ is "to facilitate and catalyze transformational change in the forest sector to lower green house gas emissions, enhance conservation of biodiversity and ecosystems, sustain community livelihoods, and stronger long term economic growth". The strategy has six thematic areas:

- Promote supply of alternate energy, energy efficient technologies and timber substitutes (supply of clean cooking stoves, establishment of environment friendly brick kilns, production of briquettes as alternative to fuelwood, promotion of processed timber and laminated wood to decrease demand for solid wood).
- Increase fuelwood supply in forested Districts (increase availability of fuelwood seedlings, develop integrated forestry models at homestead level.
- Improve livelihoods of forest dependent communities (support poor households with alternative income generating activities, support community engagement in forest management).
- Resolve forest land tenure issues (resolve land ownership in encroached settlements, resolve land related cases and writ petitions, improve coastal forest and land development and transfer mechanism).
- Improve institutional capacity (recruitment of officials and skills development training program).

- Reforest/afforest, restore and conserve (reforestation of deforested lands and afforestation of newly accreted lands, enrichment plantation of degraded forest land and conservation of existing forests; priority will be given to Hill Tracts and the coastal zone).

Under one of its main strategies of sustainable land use and spatial planning, the Bangladesh Delta Plan 2100 supports continuation of coastal afforestation to stabilize and protect newly accreted land. The plan promotes participatory mangrove plantation involving nearby coastal communities.

To implement forestry policies and strategies, a number of institutions are involved. The Forest Department (a Department of the Ministry of Environment, Forest and Climate Change) is mainly responsible for plantation establishment and policy implementation to protect forests. Among other institutions that are involved in the coastal char areas are the local administration of the Ministry of Land, the District Administration, the Local Government Engineering Department (LGED), the Bangladesh Water Development Board (BWDB) and NGOs. One can observe an increased role of community-based institutions as for instance Social Forestry Groups and Water Management Organizations.

4.2 FUNCTIONS OF FORESTS IN NEWLY EMERGED CHARS

The benefits of afforestation of coastal lands can broadly be divided into three groups: greater safety, improved ecological circumstances and a better economic situation.

Initially coastal plantations were conceived as an added protection against tidal bores and storm surges. The experience has indeed proven that this is a most important function of coastal forests. Devastation of infrastructure and loss of lives have been significantly smaller in areas that were protected by a coastal forest belt. This was demonstrated again in the cases of Sidr and Ayla cyclones in 2007 and 2009. Cyclone Sidr hit Bangladesh on 16th November 2007. Around two million households were affected. More than one million houses were damaged, but the death toll was limited to 3,500. Cyclone Aila struck the south western coastal zone on 25th May 2009. Although the human sufferings were enormous, the impact of Aila would have been more devastating if there had been no mangrove forests along the coastline. The Sundarbans forests protected the rural areas adjacent to the forests and the urban area of Khulna. Even in the event of lesser storms, houses that have homesteads with trees, time and again suffer less damage.

Char land that used to be considered as "waste land" in the past, has recently been treated as a, at least potential, valuable ecosystem. A continuation and expansion of the afforestation program in the coastal zone would increase the forest cover that can act as carbon sink. The BCCSAP of 2009 emphasizes the role of trees in enhancing carbon sequestration.

It has been found by the Vietnam Mangrove Forestry Research that the carbon (CO_2) absorption capacity of mangrove species (97.57 ton/ha) is 3 times higher than terrestrial (29.5 ton/ha) species. Conservation of coastal ecosystems, protection of wildlife and aquatic resources and protection of agricultural land against salt intrusion, are other important benefits of coastal forests. Mangrove forests protect soils from erosion, because its roots help to compact soil. Decomposition of dead mangrove leaves adds organic matter to the soil, contributing to the fertility of coastal lands. Forest plantations stimulate mud flat formation and control of erosion by dampening the impact of wind– and wave action. They accelerate the process of stabilization of newly formed chars. Mangroves serve as water filter for ecosystems linked to the mangrove forests. Coastal forests provide a natural spawning ground for fish and crustaceans, especially for shrimps and prawns. This makes the indirectly very valuable in an economic sense, because catching of fish and shrimps is an important source of income for coastal dwellers.

Initiated as a protective measure, it soon became apparent that more direct economic benefits were possible. Production of industrial raw material and fuel wood, tourism, poverty reduction through a social forestry approach, and enhancing land accretion were added to the objectives of forestry development programs. Specific economic uses are: lumber or similar construction wood; poles, fuel wood, fishing gear, etc.; raw materials for the wood-based industry of various nature and including board mills, rayon mills, match factories and charcoal products, etc.; non-timber products including tannin (mostly from bark) to supply raw materials for leather tanning industries, fishing net processing units, thatching material for roofing and raw materials for indigenous medicine; edible products including honey and wax, meat and fish, fruits, juice and sugar.

The Center for Environmental and Geographic Information Services (CEGIS) undertook an interesting study on a potential greenbelt zone in the coastal regions of the country. The study proposes a contiguous greenbelt extending from the eastern boundary of the Sundarbans to the southwest tip of Teknaf, in 37 Upazilas of nine coastal Districts. The width of the greenbelt would vary from 200 m to 1000 m, depending on the specific local circumstances, such as height of storm surges, vulnerability, presence or absence of embankment and critical infrastructure and existing forest cover. The factor vulnerability is based on a coastal vulnerability index, that takes into account exposure (among others land level, erosion, salinity), sensitivity (a.o. population density, poverty level, percentage small and landless farmers) and adaptive capacity (a.o. literacy rate, number and length of roads, number of cyclone shelters, crop production). The study report delineates a proposed greenbelt of in total nearly 127,000 hectares. A list of ideal tree species for the greenbelt was produced serving their primary purpose with sufficient economic benefits and suitable for the specific local environment. As part of the investment plan, a priority index was included in the study, with top priorities for Upazilas in the central region of the coastal zone, the subject of this book.

4.3 FORESTRY DEVELOPMENT EFFORTS IN THE COASTAL ZONE

The first experiences with mangrove afforestation were in China. It started there in the late 1950s, with a break during 1966 to 1979; it was initiated again in 1980. In order to address extreme climatic events in the coastal region of Bangladesh, a coastal afforestation program has been established since 1960-61. Bangladesh, specially the coastal areas, is a cyclone prone zone and has a serious need of protection from such calamities. The life and property of over 36 million people living along the sea front are constantly under threat from cyclones and tidal surges. Devastating loss of life and property is experienced, every time a cyclone lashes over these settlements. The offshore islands and exposed zone of the coast are the most vulnerable areas. Creation of a shelter belt along the sea front was seen as probably the most practical and affordable proposition for Bangladesh.

The Forest Department initiated the artificial regeneration of mangroves species and pioneered the mangrove afforestation techniques along the coast, thus protecting lives and properties form tidal surge and tropical cyclones. Bangladesh foresters pioneered in the field of mangrove afforestation by successfully raising about 150,000 hectares of mangrove afforestation over the last four decades along the coast and on offshore areas, mostly in the central part of the coastal zone.

The table below shows the achievements till 2001. As can be seen, a significant percentage of the new plantation is lost by erosion and by encroachment of people.

Table 4.1 Coastal Plantation during 1961-2010

Forest Dept.	Total plantation (hectares)	Failed plantation (%)			Net plantation
		Eroded	Encroached	Total	
Noakhali	70500	21	14	35	65
Bhola	37100	33	5	38	62
Patuakhali	24300	9	1	10	90
Chittagong	45400	25	14	39	61
Total	**177300**	**23**	**10**	**33**	**67**

Table 4.2 Coastal Plantation during 2010-2011 to 2018-2019

Year	Forest Divisions (Area in Hectares)				Total
	Chittagong	Bhola	Patuakhali	Noakhali	
2010-11	700,00	690,00	70,00	2735,00	4195
2011-12	3300,00	1950,00	750,00	5219,00	11219
2012-13	0,00	1150,00	250,00	2500,00	3900
2013-14	438,10	350,00	560,00	2700,00	4048,1
2014-15	600,00	702,00	700,00	2200,00	4202
2015-16	200,00	500,00	382,00	2050,00	3132
2016-17	0,00	100,00	100,00	650,00	850
2017-18	635,00	1110,00	150,00	2400,00	4295
2018-19	450,00	368,00	550,00	2600,00	3968
Total	**6323,10**	**6920,00**	**3512,00**	**23054,00**	**39809,10**

In the period 1961-2010 the plantations were implemented under the following Forest Department schemes:

1. Afforestation in the coastal belt and offshore islands (1960–61 to 1964–65);
2. Afforestation in the coastal belt and offshore islands (1965–66 to 1969–70);
3. Afforestation Project in the coastal regions of Chittagong, Noakhali, Barishal and Patuakhali (1974–75 to 1979–80);
4. Mangrove Afforestation Project (1980–81 to 1984–85);
5. Second Forestry Project (1985–86 to 1991–92);
6. Forest Resources Management Project (1992–93 to 2001–2002);
7. Extended Forest Resources Management Project (2002–03 to 2003–04);
8. Coastal Green Belt Project (1995–96 to 2001–02);
9. Coastal Char Land Afforestation Project (2005–05 to 2009–10);
10. Management Support Project for Sundarbans Reserve Forest (2005–06 to 2009–10).

The success of these programs has been highly variable. In cases of less successful endeavors, often the reason for failure has been inadequate knowledge about ecological processes in the mangrove habitat. The Bangladesh Forest Research Institute (BFRI) has worked over the last two decades to select appropriate species for the rehabilitation of degraded mangrove plantations, which are presently thought to be unsuitable for mangroves. The development of a second generation of coastal plantations has also been studied by the BFRI and it has made concrete recommendations. Site suitability, provision for the second rotation crop, encroachment and insect infection are major problems for the mangrove plantation in the coastal zone.

A major new initiative is the Sustainable Forests and Livelihood Project, supported by the World Bank. The project runs from 2018/19 to 2022/23. Under this program a total of 21,080 hectares of coastal mangrove plantations are planned to be raised in different coastal forests divisions of the country. In addition, plantations established in recent years that were damaged, mainly by human interference, will be restocked (in total 2,700 hectares).

4.4 PLANTING TECHNIQUES AND SPECIES USED

Like in most of the countries, the initial planting of mangroves started with the planting of propagules or seedlings collected from the natural forest floor. At present the commonly used planting materials are natural seedlings, termed as "wildlings"; seeds and propagules; and nursery seedlings. The Forest Department gives priority to nursery seedlings for coastal plantation raising. Successful nursery practices have been developed in Bangladesh for raising seedlings of certain mangrove species.

In general nurseries are raised during December and January. Planting of seedlings is preferred over direct sowing of propagules. The matching of species to specific micro-sites is very important in mangrove afforestation. The exact needs have to be determined before a nursery is established. Only young vigorous and healthy seedlings are to be used after culling at the nursery site. Transportation of seedlings by boat is recommended which prevents them from being exposed to a non-coastal, non-saline environment. Generally, about 60 cm. Tall seedlings are used for planting though taller seedlings are preferred for areas subjected to higher inundation, but no seedling over 1.5 meter in height should be used. In general, the planting should be done at the beginning of the rainy season. In addition, the lunar calendar should be considered for fixing the planting period, which should be one week beginning from the fifth or the nineteenth lunar dates.

The success of mangrove afforestation is closely linked with the intensity of beating up operations (filling open spaces) and after care, including the choice of species for the given micro-site. Generally, up to the third year of plantation, beating up operations are to be done. The site characteristics to be considered for the selections of species are (1) area covered by tide; (2) tide inundation heights; (3) run-off and tide velocity; (4) salinity of tide water; (5) fresh water inflow; (6) sediment load in the tide water; (7) soil texture; (8) physical exposure to tidal wave action and (9) ocean water temperature. The three most important ones of these nine characteristics are soil texture, water salinity and inundation levels. Above all, field experience has no substitute on this issue.

Generally, 1m x 1m spacing is used for planting. Species planted are mainly Sonneratia apetala, Rhizophora and Bruguiera. Rhizophora conjugata and

Rhizophora mucronata propagules are planted at 1.2 m x 1.2 m and 1.8 m x 1.8 m spacing, respectively.

Mangrove afforestation requires a period of about 75 days of “intensive care” from the date of planting. Replacement of washed-off, eroded, crab damaged, sickly and dead seedlings needs to be undertaken along with action to facilitate drainage, remove rubbish and dump brush wood to combat erosion.

The most used non-mangrove species is coastal areas (for example roads– and embankment plantations) are acacia, silk trees (Albizia procerra en Albezia chinensis), rain tree (Samanea saman) and Jhau (Casuarina spp.).

Experience in Char Development and Settlement Project III and IV

The species planted in the social forestry program of CDSP III, have been selected on the basis of the suitability of the species to the specific plantation site, the preference of Social Forestry Group members and the silvicultural characteristics of the species. Mostly fruit–, timber–, medicinal– and fodder trees were used. In total 2,638,500 seedlings were planted & maintained (up to June 2010) throughout the project area (of around 6,000 ha.). At present, on average, the survival percentage is 70-75 percent. The gaps are filled up in the months of May and June in the year after planting.

In case of strip plantations, fast growing multipurpose and fruit species on a production-sharing basis were planted. A multi-story vegetative cover was applied, which was suitable for embankment and road plantation, including grass, fruit species and legume crops, for example Arhor (Cajanus cajan). The species that have been selected for roads and embankments fulfilled a number of additional criteria. For example, they should serve as a soil binder, prevent erosion and stabilize the side slopes. Plants established on the lowest levels were tolerant of at least short-term inundation. Species like Acacia, jarul and Dalbergia sissoo were chosen for patches that were known to be under water for a period of time. Trees and mixed vegetation on the riverside slope and toe were planted thick and continuous to protect the lower bank. Usually, three to five rows of plants were put on each face of the embankment. The length of infrastructure required for 1 ha. Of planted surface for 5 meter slopes is 1 km.

In total 17 different species have been planted alongside roads and on the slopes of embankments. Three species were used for mangrove plantation and 11 species in the village afforestation program. In case of trees planted in roadside plantations Acacia auriculiformis (Akashmoni), is the highest in number which, is about 30 percent, followed by Jhau, mehagoni and arjun, which are 28, 12 and 10 percent respectively of the total trees planted on road sides. In case of embankments, almost 50 percent Jhau have been planted and maintained.

In a roadside plantation, the trees are usually planted with a 6.5 ft x 6.5 ft (about two meters) spacing, which means that in case of one kilometer roadside plantation (2 km planting length), approximately 2,000 seedlings were planted. Roughly 2,550 seedlings were planted in 1 km of embankment length. On average, 3-4 rows of seedlings have been planted on the country side and 4-6 rows on the sea side of the embankment.

In order to enhance the short term benefits from the road– and embankment plantations, the Forest Department initiated inter-cropping, with various short rotation crops. Additional benefits were that through inter-cropping, the ground cover was improved and the young and tender seedlings were protected from cattle browsing and adverse human interference. Arhor (Cajanus cajan) seeds were sown along the roads to establish a protecting hedgerow. Arhor created a source of income by selling the beans, while at the same time it provided fuel wood, which meets an urgent need in Boyer Char. Also, vegetables were used as intercrops.

Typical for the dynamic character of central part of the coastal zone, the forestry development in CDSP IV was hampered by erosion. The erosion of embankments and the late construction of retired embankments caused that the project could only implement 35 km rather than the targeted 50 km of embankment plantation. Foreshore plantations were impeded by existing occupation of foreshore land as well as by erosion; of the planted 200 ha, 65 ha were lost. Also, the block plantation and road– and canal-side plantation suffered due to erosion., with losses between 10% and 15%. More than half of the 7,400 ha of mangrove plantations were lost, caused by erosion, occupation by the army and encroachment by settlers. In CDSP IV mangrove watchers were introduced to protect mangroves from destruction by buffaloes.

4.5 SOCIAL FORESTRY IN PRACTICE

4.5.1 The Concept and the History in Bangladesh

Concept of Social Forestry

In Bangladesh, as in most other countries, the term Social Forestry is used as an umbrella term for such public, private and community initiatives which aim at ensuring active participation by the rural people in planning, implementation and benefit-sharing of tree growing schemes. Social forestry refers to the way plantation activities are carried out, not to the type of activities as such. It can therefore encompass any sort of plantation, such as afforestation programs on marginal lands, agro forestry on farms, strip plantations among roads and embankments, village afforestation schemes and others. From an ideological perspective, social forestry clearly targets socially and economically vulnerable sections of society (rural poor, landless households). Commonly accepted objectives of social forestry include:

- Empowerment of local communities by involving them in planning, decision-making, implementation and benefit sharing of forestry activities;
- Promotion of self-reliance and social equity among people;
- Augmentation of income, productivity, status and livelihoods;

- Environmental protection of soil and of water resources;
- Fostering the development of local cooperative institutions.

History of Social Forestry

Until the early 1970s, it was thought that the development of natural resources by governments would automatically "trickle-down" in most forestry projects in developing countries so that the benefits would eventually reach the rural poor. Major development activities were large scale and forestry management was centrally driven. Forestry was technically oriented (tree centered) and forest departments were typically mandated to both exploit and "protect" or "conserve". The failure of many forestry development programs proved, however, that the "trickle-down" process was not working and would not work. One of the earliest institutional responses to this realization was a program of the FAO called "Forestry for Local Community Development". This received an international boost with the holding in 1978 of the Eighth World Forestry Congress in Jakarta, Indonesia, with the theme "Forests for people".

Policing and enforcement activities failed to protect the Government forest estate. This was true internationally, but certainly also in Bangladesh. It was recognized that Government staff could not provide effective services to rural people without institutional development and support. Many governments felt that there was no alternative than to involve villagers as, active partners with government, in the protection, planning, management, utilization and further development of forests, and in practices encouraging more trees on farms.

Experience in Bangladesh with social forestry approaches actually preceded the international attention to the subject in the late 1970s. Already in 1967 a social forestry project was taken up by entrepreneurs like Mahbubul Alam Chashi, Mohammad Eunus and Abdul Alim at Betagi and Pomora, two remote denuded hills in Rangunia thana of Chittagong district. The project aimed at regenerating these hills by planting trees, rehabilitation of landless farmers (in total 226 families) and protection of the forest from illegal felling with the help of the settlers. On a wider scale, the social forestry concept and approach was introduced in the early 1980s, notably with the start of a community forest project financed by the Asian Development Bank (ADB), with technical assistance from UNDP through FAO. The project ran from 1982 to 1987 and was operational in seven Districts, namely Dinajpur, Rangpur, Pabna, Rajshahi, Bogra, Kushtia and Jessore. The tangible objectives were to increase the supply of fuel wood, fodder, fruits and other products. Central to the project were a participatory approach in raising fuel wood, raising awareness among farmers about the importance of forestry for the community and using demonstration farms on agroforestry. A social forestry training institute was established in Rajshahi. Based on the success of this project, the Government and ADB agreed on a follow-up, the "Upazila Afforestation and

Nursery Development" project. This was a countrywide project covering all parts except the Sundarbans and the Chittagong Hill Tracts. The main components were raising plantations in depleted forest areas; establishment of agroforestry farms; establishment and support to 51 Forestry Extension Nursery and Training Centers; distribution of about 45 million seedlings; training of village leaders and Forest Department staff; establishment of nurseries.

Important for the coast was the Coastal Green Belt project, operational in 10 Districts in the coastal zone. It is based on the principles and experiences of the aforementioned "Upazila Afforestation and Nursery Development Project". The Coastal Green Belt project ran from 1994/95 to 2000/01 and was also financed by the ADB. The objective of the project was to reduce loss of life and damage to property caused by cyclones through increased vegetative cover in the project area. Increasing the vegetative cover will be realized by the promotion of coastal tree planting activities among the local population with the involvement of non-government organizations (NGOs).

The National Forest Policy of 1979 clearly laid down the participatory approach to be followed in Government owned forest land and plantations on marginal land. In 1982, supported by this policy, the Asian Development Bank (ADB) assisted the first community forestry project which was located in the northern part of the country, in a recognized environmentally degraded zone.

The social forestry program has been institutionalized through reorganization of the Forest Department. The history of social forestry in Bangladesh is linked with the introduction of forest extension services in the Forest Department. During 1962-63, two forest extension divisions, one at Rajshahi and the other at Dhaka were created and the tree planting day on the 1st of June was introduced. Since the creation of these divisions for the growth and distribution of seedlings, a gradual expansion of activities has taken place. In the reorganization of the Forest Department in the year 1999, a Social Forestry Wing was established. A Wing indicates the magnitude of the works and line of jurisdiction. It is administered by a Deputy Chief Conservator of Forest. The Wing consists of three Social Forest Circles, 13 Social Forest Divisions, 98 Social Forestry Nursery Training Centers and 341 Social Forestry Plantation Centers. Their task is to make operational, implement and administer the social forestry activities as they were defined in the National Forestry Policy of 1994.

To create awareness among people, motivate participants, local leaders as well as staff of the Forest Department, a large number of training programs was arranged under different projects and schemes. In the beginning, participation of the local people in plantation programs was not significant. However, with the passage of time and after getting training and being exposed to publicity from different print and electronic media, people's participation in social forestry activities increased dramatically. From the Community Forestry Project (1981-82 to 1986-87) to Forestry Sector Project (1997-98 to 2005-06) more than 30,000 persons have been trained, among them beneficiary participants, local leaders and NGO workers.

4.5.2 Social Forestry Groups (SFG)

Formation of SFGs

According to the Social Forestry Rules 2004, amended in 2010, in general, local people living around a 1.0 km. radius of the scheme site are considered as beneficiaries or participants. No beneficiary shall be below the age of 14 years. A group should have between 12 and 15 members. The members should form a part of the scheme's original labor pool and should continue to invest their time and effort in maintenance and other scheme activities throughout the scheme's lifetime. For social forestry schemes, at first NGOs are selected and recruited for the selection of participants, their training and motivation. With the help of Union Parishads, local forest officials and NGOs are primarily responsible for the selection of the beneficiary participants and the formation of groups among the beneficiaries. These should be selected from the lower-income and/or disadvantaged or vulnerable socio-economic strata of the local population, i.e., landless (0.5 acres or less), widowed/separated or destitute women, and indigenous people. Preference is given to the selection of women beneficiaries wherever possible. Later the selected beneficiaries list must be approved by the Upazila Paribesh o Ban Unnayan Samannyan Committee (Upazila Environment and Forest Coordination Committee). After that a Participatory Benefit Sharing Agreement (PBSA) among the parties, including Forest Department (the Divisional Forest Officer is the main party representing Forest Department), must be signed and distributed to all concerned. NGOs and Government agencies are also required to seek alternative or additional sources of income generating activities for the group members. They should be encouraged to make regular monthly savings.

In cases where NGOs are not available or provisions of NGOs recruitment are not accommodated with in the concerned project proposal, the matter of selection of participants may be referred to the Forest Department.

Benefit Sharing Agreements

The Forest Department and land owning agencies have to sign a Memorandum of Understanding (MoU) regarding the use of marginal lands for Social Forestry programs. For instance, the Forest Department signed a MoU with Bangladesh Railways on the 29th of May 2000; with the Local Government Engineering Department on the 13th of July 2000; with the Bangladesh Water Development Board on the 29th of September 2000; and with the Roads & Highways Department on the 13th of April 2002. It is essential to protect the interest of the participants involved. Therefore, a PBSA is signed between the Forest Department, NGOs and land owning agencies. Long term involvement of participants has been ensured through the PBSAs. It will provide sustainability to the plantations.

According to the Social Forestry Rules, the benefit sharing arrangements after final harvesting is given in Table 4.3.

Table 4.3 Benefit Sharing Arrangements in Social Forestry

In case of woodlot and agro-forestry plantations established on lands under the control of Forest Department, the benefit sharing ratio would be:	
Forest Department	45% of the total benefits
Participants	45% of the total benefits
Tree Farming Fund	10% of the total benefits
In case of strip plantations raised on the lands owned by public or statutory body other than the Forest Department, the benefit sharing ratio would be:	
Forest Department	10% of the total benefits
Participants	55% of the total benefits
Tree Farming Fund	10% of the total benefits
Land Owning Agency	20% of the total benefits
Local Union Parishad	5% of the total benefits
In case of Sal Coppice Management, the benefit sharing ratio would be:	
Forest Department	65% of the total benefits
Participants	25% of the total benefits
Tree Farming Fund	10% of the total benefits
In case of existing plantations and natural forests, except Sal Coppice Management, the benefit sharing ratio would be:	
Forest Department	50% of the total benefits
Participants	40% of the total benefits
Tree Farming Fund	10% of the total benefits
In case of social forestry in the forest land invested by local community people, the benefit sharing ratio would be:	
Forest Department	25% of the total benefits
Participants	75% of the total benefits
In case of social forestry on land of Government-, semi-government- or autonomous organizations invested by local community people, the benefit sharing ratio would be	
Forest Department	10% of the total benefits
Participants	75% of the total benefits
Land owning agency	15% of the total benefits

The local community has to tend to the trees and maintain them after they are planted. The protection of trees from damage due to grazing, illicit cutting, etc is of great importance.

4.5.3 Experience in CDSP

In CDSP III, the social forestry approach was followed as a strategy to secure access to a particular type of resources (trees) for the settlers in Boyer Char. The process of formation Social Forestry Groups began with discussions and awareness raising meetings with the members of the community and local leaders, to inform them about the legal aspects of SFG formation, the role that communities could play and the benefits that could be accrued by SFGs. In total, 85 such motivational and awareness meetings, in different places at Boyer Char, were organized. These meetings were followed by a quick survey, using structured questionnaires, for the selection of appropriate beneficiaries for road–, embankment–, and foreshore plantation, as well as for village afforestation activities. The final selection of the project beneficiaries was done through a series of consultation meetings with Water Management Groups (WMG), members of the local elite, and NGOs. The Forest Department was in charge of the selection process, with the help of staff of the technical assistance team.

Table 4.4 SFG Formation in CDSP III

Name of the Activities	Nos. of SFG	Male members	Female members	Total nos. participants
Roadside Plantation	62	966	585	1551
Foreshore Plantation	23	350	187	537
Embankment Plantation	28	363	239	602
Mangrove Plantation	14	210	130	340
Total	**127**	**1889 (62%)**	**1141 (38%)**	**3030**

In CDSP IV a total of 630 SFGs have been formed, of which 49 have lost their trees due to erosion. Over 40% of the SFG members are women.

In principle, one SFG was formed for every 1 km roadside plantation, 0.75 km embankment plantation, 12-15 ha. Foreshore– and 20 ha. mangrove plantation. As the table shows, in total, 127 social forestry groups were formed each with 25-30 participants (of the total 3030 members, 1,141women, 38%, and 1,889 men, 63%). Each SFG has chosen its own name, to stimulate cohesion among the members and for easy identification and future documented recognition from other SFGs and groups. Officials of the Forest Department field staff maintain regular contact with the SFGs and attend the monthly meetings.

In Boyer Char, the social forestry strategy brought about an important breakthrough in the, until then, strained relation between the Forest Department and the char dwellers. After years of a rather tense situation, due to the illegal migration into land that was planted and controlled by the Forest Department, the atmosphere changed. The social forestry approach changed the attitude of the foresters towards settlers; at the same time, the settlers became more sympathetic to the Forest Department staff because they saw the importance of afforestation for their environment as well as its economic benefits through work opportunities and as a source of additional income. The benefit sharing agreements formed as it were the icing on the cake as the formal confirmation of the new circumstances.

Land lease agreements and benefit sharing agreements were entered into, with the respective land owning agencies, SFG members (who are the primary beneficiaries of the project) and the Forest Department as parties. As of May 2010, in total 52 deeds have been distributed among 1,334 SFG members, i.e., project participants. Out of the 52, 45 deeds are for roadside beneficiaries and seven deeds for embankment beneficiaries.

4.6 COPING WITH THE IMPACT OF CLIMATE CHANGE THROUGH COASTAL AFFORESTATION

The Forest Department considers expansion of the mangrove plantations as a prime weapon against the impact of climate change induced sea level rise. As anyone who has spent any amount of time in mangroves knows, these forests are flourishing in some of the toughest places on earth. Subject to rapid daily, monthly, and annual variations in their physical environment, they have a striking ability to cope with extraordinary levels and types of stress. The innate resilience of mangroves to cope with change is a remarkable and highly valuable property, that should be exploited in the struggle with the consequences of global warming. Unfortunately, to date that attribute have largely been ignored in devising mangrove management programs. If the millions of coastal residents who benefit from the services provided by mangroves are to survive and continue to enjoy the enormous advantages provided by healthy mangroves, then we need to quickly and proactively develop climate change-oriented mangrove management programs. These programs have to take into account the effects of upstream development on sediment supply and the synergistic effects of human-induced and natural change.

Mangroves have adapted special aerial roots, support roots, and buttresses to live in muddy, shifting, and saline conditions. Mangroves may adapt to changes in sea level by growing upward in place, or by expanding landward or seaward. Mangroves produce peat from decaying leaves, in combination with the trapping sediment in the water. The process of peat formation helps to raise the level of the land. Mangroves can expand their range, if the rate of sediment accretion is sufficient to keep up with the sea-level rise.

With a view on climate change, the value of mangroves can hardly be underestimated, especially its property of protecting coastal areas against cyclones and storm surges. It is expected that the peak intensity of tropical cyclones may increase with 5-10%, which would lead to enhanced storm surges and coastal flooding. Cyclones may penetrate further inland and cyclone High Risk Areas are likely to increase in size. Currently, about 8.3 million people live in such High Risk Areas. This could increase to 15 million in the 2020s and to over 20 million in the 2050s, caused by the combined effect of population growth and the expansion of the High Risk Areas.

4.7 CONCLUSIONS AND CONSIDERATIONS FOR FUTURE COASTAL DEVELOPMENT PROGRAMS

Benefits of Social Forestry

Overall, the introduction and promotion of the social forestry approach can be seen as a success. On the economic side, it is estimated that the increase in supply of forest products contributed 4% to the country's GDP. For many rural households, as is shown in the case of CDSP III and IV, the additional production and the benefit sharing mechanisms have had a pro-poor effect. At the same time, the negative impacts of deforestation as a consequence of illegal encroachment has been mitigated by afforestation schemes based on social forestry principles. The uptake in forestry development activities, partly as a consequence of the emphasis in policies on people's participation, have had an impact on soil and water conservation and on maintaining bio-diversity. Any future coastal development program should have a forestry component, based on social forestry principles.

Expansion of Area Under Social Forestry

An important element for planning of future schemes is to assess the potential in terms of available land for social forestry activities. For the whole country the estimated potential is given in Table 4.5.

Table 4.5 Potential of Additional Land for Social Forestry in Bangladesh

No.	Available land	Area in million hectares
A	Degraded and denuded land of Unclassified State Forest Land	1.00
B	*Khas* lands	0.56
C	Degraded government forest land	0.27
D	Marginal strip land	0.08
E	Homestead marginal land	0.27

Continued

Table 4.5 Continued

No.	Available land	Area in million hectares
F	Degraded tea garden land	0.06
G	Degraded private forest land	0.05
H	Agroforestry on private agricultural lands	2.36
(29% of the total agricultural land is above normal flood level and suitable for agroforestry)		
Total available land for social forestry		**4.65**

In total, about 4.65 million hectare is available for this purpose, which is about 31% of the country's total land surface. Considering the size of Bangladesh and her forest area, the potential land available for social forestry production system is quite significant. At the moderate rate of 10 cubic meter per hectare, the area could produce 46.5 million cubic meter of timber. Moreover, the system would provide food, income and employment opportunities for the farmers.

The table applies to the whole of Bangladesh. The CEGIS report on a potential coastal greenbelt (see section 4.2) envisages a greenbelt of in total 127,000 hectares.

Funds Required for Mangrove Plantations

The CEGIS study can give a first indication of how much funds would be required to indeed expand the area under mangrove forests. This will most likely be substantial. To generate the necessary funds, multiple sources should be tapped. The Government should increase the development– and the revenue budget for the Forest Department, while funds should be solicited from multilateral– and bilateral donors. Proposals should be prepared and submitted to the already existing climate change funds. In addition, the feasibility for public/private partnerships for forestry development should be investigated.

Social Forestry Schemes in Mangrove Plantations in Early Phases of Char Development

In many cases the afforestation efforts of the Forest Department are thwarted by encroachment of settlers who are desperately in need of a new livelihood base after loosing their land through erosion. Creative solutions have to be thought of to balance, on the one hand the need of afforestation for water and soil conservation and of stabilization of newly formed lands with, on the other hand, the need to settle what can be called environmental refugees. As was argued in Chapter 2, there is a need for an improved land management system in the period between the moment that the land has emerged and is turned over to the Forest Department and the moment the land is handed over to the Ministry of Land. A key feature of such a management system would be the application of social forestry principles to the plantation and conservation of mangrove forests (as promoted in BDP2100). If people can be convinced that mangroves are important for their future livelihoods through land stabilization and at the same time are of value for their present livelihoods (through a stream of income from benefit sharing arrangements), illegal encroachment could be reduced and even stopped. At the same time, alternative means of livelihoods should be developed, to reduce the pressure on mangroves.

Knowledge Dissemination

Given the importance of afforestation in the process of coping with the consequences of climate change, it is essential that knowledge and information is widely distributed to the coastal population as well as to staff of the Forest Department and concerned NGOs. Large scale campaigns and training programs should be developed. The function of forests in strategies to address climate change should be the main topic in such programs. The Social Forestry Groups can play a crucial role in the efforts to reach and involve coastal communities.

The transfers Forest Department staff from coastal to other areas and the influx of new staff in the coastal areas, makes it mandatory that flexible training opportunities are available. Staff newly posted in the coastal zone, should receive training on topics and skills, tailored to the coastal circumstances. At the same time, changing insights and new technologies require frequent refresher courses for coastal Forest Department personnel.

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Chapter 5

Wild Fisheries and Aquaculture

Dr. Harvey Demaine

5.1 INTRODUCTION: LIVELIHOOD TRANSITION FROM FISHERIES TO AQUACULTURE

Other chapters of this volume have described the process of formation of the char lands of southern Noakhali, the steady consolidation of the land mass, partly through development of dykes and cross-dams, and the largely unplanned and illegal process of settlement of the area by landless households. These settlers came mainly from river eroded areas of the Meghna estuary, including the islands of Hatiya, Bhola and, to a lesser extent, Sandwip. Given that many of these settlers were traditionally from fisherman families on the islands, as they settled in the new chars, they naturally attempted to re-establish their livelihoods through the same occupation. At the same time, as a common property resource, the fishery has become a new livelihood focus for many other displaced families, previously not involved in it. This situation is demonstrated by the changing religious composition of the fisher communities in the area. Fishing has traditionally been the profession of the lower caste Hindu community. However, at present only 23% of all fisherman groups in Hatiya are now Hindu, although this rises slightly to almost one-third among boat owners and to 27% among others involved in full-time fishing occupations such as crab catching, post-larvae catching and fish processing.

Moreover, over time, as the chars have consolidated, the opportunities for full-time marine fishing have declined and former fisher households have begun to adapt to alternative livelihood opportunities. Thus the chars exhibit a fascinating transition in the aquatic livelihood of these households from full-time marine fishing through the trapping of wild fish of both marine and freshwater species in open ponds to the gradual adoption of aquaculture as the availability of wild fish declines and the catch per unit of effort in the fishery falls. Different parts of the chars show different stages in this transition according to the degree of access to open water or, put in another way, the balance between sea and land.

This chapter describes this transition through information derived mainly from three feasibility studies of the sector in the so-called "new chars" (Char Nangulia, Noler Char, Caring Char) and, by different authors, of Urir Char, conducted for the Char Development and Settlement Project, Phase III in 2006 and 2008 and updated from the Baseline Survey of the fourth phase of CDSP (CDSP IV) and the Baseline Survey of its Social and Livelihoods Component of those chars published in 2012 and 2013. The focus is overwhelmingly on these new char areas, with some minor reference to the larger fishery on Hatiya island, where erosion on its northern side has been compensated by some recent accretion beyond the South Hatiya Polder dyke on the south and southeast of the island.

Attention is consecutively given to coastal fisheries, inland fisheries and aquaculture. A major part of the chapter describes work carried out by successive Danida-funded projects, the Greater Noakhali Aquaculture Extension Project (GNAEP) and the Regional Fisheries and Livestock Development Component, Noakhali (RFLDC) in promoting the development of a range of different aquaculture options in the context of the varying aquatic environment of the Noakhali chars. This ended in 2013 and the review also draws from a consultant report seeking to integrate the work of the RFLDC Project into the Social and Livelihoods Component of CDSP, conducted at the end of that same year.

5.2 COASTAL FISHERIES

An important minority of the settler population in the new chars makes its living from marine fisheries. Three main types of fishery are practiced:

a. Offshore fisheries for hilsa and other fish species, especially the small goby, chewa. This is the major fishery in Hatiya; in Urir Char, it is practiced by a minority of families but is important in economic value (5.2.1);
b. Inshore catching of the seed (post-larvae) of shrimp and prawn, practiced by large numbers of households as a supplementary occupation, often by children and women (5.2.2); and
c. Inshore crab catching, carried out only by a small minority, but of growing importance as a potential export commodity (5.2.3).

5.2.1 Hilsa and Chewa Fishery

An attempt was made to estimate the number of households involved in coastal fishery in the then unprotected chars of Char Nangulia, Noler Char (including Char Rahman) and Caring Char in 2007-8. It is difficult to identify the total number of fishermen in each Char since most fishermen are well aware of government rules banning *jatka* (hilsa juvenile) catching and they commonly try to hide information. However, by seeking information from different sources, it is possible to come to some estimates.

It appears that the proportion of fisherman households decreases with distance from the Hatiya channel. Thus, in Caring Char, on the seaward side, around 15-20%

of all households are coastal fishers, probably giving a total of 500-700 households; in Noler Char, the proportion drops to 10-15%, but the higher number of settlers gives a total of 1,000 households. The proportion rises to 20% in Patar Char-Koen Char and Char Rahman adjacent to the Hatiya river. Finally, in Char Nangulia, some 5-8% of households are fishers, with a total of perhaps 1,500 households. In short in the new chars, there may be around 3,000 coastal fisher families, out of a total of approximately 16,000 households. In the island Urir Char it is estimated that 15% of households are working in coastal fisheries. In all of the new chars, the proportion of households engaged in fishery is lower than in the more established fishery on Hatiya island, where between 24% of households and 28% of the population were engaged in fishery in 2008. However, these figures from Hatiya include households engaged in fish drying as a specific occupation.

Table 5.1 from the CDSP 2012 Baseline surveys gives rather lower figures but with a similar pattern for the mainland chars. These reports also offer global average incomes from fishing, which, because of the relatively small proportion if fishers, are no more than 3% of annual income.

Table 5.1 Key Variables Related to Fishing in New Chars

Variable	Char Ziauddin	Char Nangulia	Noler Char	Caring Char	Urir Char
Fishing as Principal Occupation (% Households)	4	1	3	5	2
Income from Fishing	1,150	1,631	2,620	2,573	2,780
Total Household Income	**65,743**	**69,15 2**	**69,281**	**71,475**	**104,400**

Source: CDSP-IV Baseline Survey Report, February 2012; Base Line Survey of Social and Livelihood Component.

Note: CDSP IV includes Char Ziauddin which was settled around the year 2000, but was not included in earlier phases of CDSP and still had land available.

The fishers in these new chars are mostly migrants from Hatiya. Before migration from Hatiya, they were involved with fishing in the Hatiya channel and in the Meghna Estuary some 10-20 km offshore of the island, as their main occupation. On Hatiya, this same fishery continues as a major occupation, with the chewa catch slightly greater than that of hilsa.

The fishermen from the new chars continue to go to the same location for fishing for long periods (7 days to 30 days). For Urir Char, the fishing location is more varied. Apart from the Meghna estuary and the Hatiya channels, some fishers go to the mouth of the Bamni and Feni rivers to the north.

Different fish and shrimp/prawn species are caught in different seasons. Hilsa (Hilsa tenulosa) is caught from mid-June to mid-October (about 4 months), while *jatka* (hilsa juveniles) are caught from mid-February to mid-May (about 3 months). Chewa fish are caught from mid-November to mid-March (about 4 months) in the Meghna river and the Hatiya channel about 10-20 km far from Hatiya shores (Figure 5.1). The study of Hatiya points to the important overlap between the end of the chewa catching season and the beginning of the availability of *jatka* and the impact of the ban on *jatka* catching on the chewa fishery.

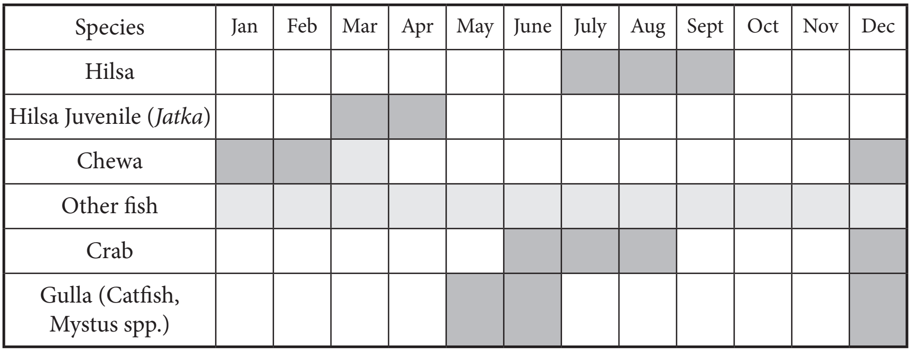

Figure 5.1: Seasonal Calendar of Fishing Activities in New Chars.

In the much more established fishery value chain in Hatiya, chewa fish are sun-dried in the chars before sale, mostly by women, including the heads of women-headed households in the community. The Hatiya survey suggests that fish drying is the main occupation of 32% of the fishery related households, comprising over 90% of women-headed households, but also women members of 26% of boat owning households and 10% of laborer households. In the less extensive system in Urir Char, chewa fish are sold to depots without drying. There are opportunities to catch other fish species like Pangas, Bata, Ricksha and Gulla all round the year.

The Hatiya study identifies two groups involved in the main fishery, the boat owners (*Maji*) and laborers; typically a crew of around ten persons are hired by the boat owners. In Urir Char, most fishermen do not have their own nets or boats (only 5% of fishermen have their own nets in joint ownership with others). Thus, they have to go to the moneylender to take a *dadun* (advance money for boat and net repair/renewal). Most of the *dadunder*s (money lenders/depot holders) are resident in Hatiya. Some people in the older chars (such as Char Majid and Char Bata) and a very few in the new chars themselves also rent out small-size fishing gears to the local fishermen.

The conditions related to renting fishing gears are as follows:

- The fishermen who take *dadun* (advance money) have to sell their fish to their respective moneylender/fish depots. Fishermen have to pay a 5-20% commission on their total sale (for small to bigger boats and nets) to the moneylender/depot holder. With regards to sharing of the profit with the gear owner, in the case of a small boat, the net return is divided 50-50 on total catch; in the case of bigger boats, the gear owner gets 60% of total catch. In both cases, expenses will be borne by the gear owner.

- Another type of fishery is found in Caring Char commonly known as "line fishing". Fishes are caught through hooks arranged along a nylon thread. Hooks are hung on a thin thread (1-1.5 ft long) from other long ropes, which may be up to 1.5-2.0 km long. These lines contain 1,000-1,500 hooks. The lines are fixed in a tidal area with bait on each hook at low tide. During the high tide, the hooks are released. One kind of catfish (Mystus sp.), locally known as Gulla, is caught on this long-line. During low tide the fishers use a boat to collect the fishes trapped on the hooks. This fishery only lasts 2-3 months in the rainy season, from mid-April to mid-June. Although the description above reflects the relatively recent situation (2007-2009), the livelihoods of these inshore fisher households are coming under increased pressure from environmental changes in the fishery, partly caused by siltation of the Meghna estuary, partly by the effects of overfishing, as well as from socio-political pressures such as government bans on certain fisheries, such as *jatka* and shrimp and prawn post-larvae catching (see below). Such households have few other opportunities since land-based activities are high risk as a result, in particular, of tidal surges and salinity intrusion.

It is also in these areas where the effects of climate change will be most pronounced and where there is most urgent need for adaptation to the steadily changing and worsening environmental situation. Even if there is not widespread inundation, which in the Noakhali region may be offset by raising the height of the dykes and the general siltation trends, risks of extreme climatic events will be exacerbated and with them the threat to livelihood both on land and at sea. Steps need to be taken now to assist local communities to analyze their situation and begin a process of adaptation.

5.2.2 Catching Post-Larvae of Shrimp and Prawn

One of the most important livelihood options for the people of new chars is catching of post-larvae (PL) of shrimp (Bagda: Penaeus monodon) and prawn (Golda: Macrobrachium rosenbergii). People living on the riverbank or near the riverside are mostly involved in this occupation, with the proportion varying according to the individual chars, 70-80% in Caring Char and 50-60% in Char Nangulia and Noler Char. People living far from the river are not so involved. Unlike the hilsa and chewa fishery, post-larvae catching mainly forms a source of supplementary livelihood for poor households. The PL catchers vary in age, but many are women and children, most of them (50-60%) children between 6-15 years old. Of these, 20-30% are females (including girls). The reasons for children's involvement in PL catching are that they have no educational opportunity or alternative income sources among families leading a hand to mouth existence. Some women at the riverside are also catching PL in breaks between their reproductive activities. Most PL are caught during the night tides, when people assume that a larger amount of PL can be caught. Adult males (mostly) catch PL at night and then go for work (as laborers) in the day. If PL are widely found available both day and night, they become involved full time for PL catching. Children and women mainly catch PL on the day tides (although some catch at both times.)

As noted above, there are two types of PL caught by the catchers: Bagda and Golda. The Bagda PL catching season is longer than that for Golda (Figure 5.2). Bagda PL catching starts in late November and ends in June. Out of these seven months, December and January are the peak months of Bagda PL abundance. On the other hand, the Golda PL catching season starts from mid-March (mostly from April) and ends in June. April and May are the peak season. Most PL are caught during the full moon and the new moon, when the tidal effect is higher. Catching behavior differs between the two species; Bagda are caught during the high tides and Golda during the low tide.

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dce
Golda PL Catch					Peak Time							
Bagda PL Catch	Peak Time											Peak Time

Figure 5.2: Seasonal Calendar of Golda and Bagda PL Catch

PL are caught by a small mesh net, rather like mosquito nets, often obtained on *dadun* from the small traders, with the fishers' returns being adjusted from their sales. PL-catchers without *dadun* purchase nets from markets in the upper chars by cash. The net size and catching system varies from person to person. Some nets are fixed with bamboo poles against the tidal flow and the cod end tightened. Children also use small triangular/or rectangular nets for PL catching. After a certain period, PL and other larvae are collected in a bucket. The Bagda and Golda PL are then sorted out. In most cases, the by-catch is not released back to the river. Even if somebody wished to release the by-catch, in most cases the larvae die during the sorting period. The catchers, who have taken *dadun*, may also have a small boat and 3-5 nets under each boat to collect PL with other family members (2-3 in average).

All of the PL from the new chars are sold to depot holders at Chairman Ghat in Boyar Char (with 18 PL depots) and at three bazaars in Char Nangulia (with 17 PL depots between them). The PL is delivered to the depots either though a hawker, or by the individual catchers themselves. Hawkers are predominantly working in those areas without depots, as Caring Char and Noler Char. All of the hawkers in the chars take *dadun* from the depots, while the PL catchers in turn take *dadun* from the hawkers. Each hawker has around 50 fishermen in his network. In each of the PL catchers' households, 1-3 family members are involved with 4-6 nets.

It is estimated that approximately 11,500 people are involved in PL catching: Char Nangulia 4,000, Noler Char (including Patar Char-Koen Char and Char Rahman) 4,500 and Caring Char 3,000. The total value of the supply of the PL to the depots was estimated at about Taka 23 million (in 2006). Based on a rough calculation and on information derived through interviews with PL catchers, the income for each involved household is probably between Taka 5,000 and Taka 10,000 a year. This means it is a very important source of income for them.

Although the Government of Bangladesh has banned the catching of any type of PL and fish larvae from natural sources, for the people of the new chars, it forms an essential part of their livelihood. Not only the ban is endangering this stream of income, also the decline of natural PL in the waters around the chars has an adverse impact. People are aware of the prohibition on PL catching from the rivers but they do not have alternative income options. The Department of Fisheries has launched a number of alternative income generating projects, but these have been largely ineffective, so local people still need to be involved with PL catching for their daily income. If the ban on PL catching were strictly enforced by the government, they would face great problems, with a severe reduction in earnings, which are already under pressure by the decrease in PL numbers.

5.2.3 Crab Catching

Crabs are traditionally caught by the Hindu minority. Like post-larvae catching, crab catching is usually a supplementary occupation to fishing, not a full time pursuit. The fishermen catch crabs when they are free of other activities. They catch the crabs during low tide when the water level declines from holes in the tidal areas of the river and canals using a rod made of iron with a curved head, locally called "Tota".

Crab catching appears to be growing in importance because of the emergence of an export market. In Urir Char, the island char off the coast of Companiganj Upazila of Noakhali, 10 years ago only 15-20 people were engaged in crab harvesting. However, by 2009 around 300 people are involved in this activity. They come from Subornachar, Companiganj, Feni and Sitakunda and live temporarily in Urir Char. They harvest crab

Table 5.2 Crab Grading and Grade Wise Price

Grade (gm./pc.)	Price (Tk./pc.)
400	30
300	15
250	10
180	12
150	10
120	8

from the forest side canals, internal canals and the riverside. A person can harvest 100-120 crabs a day during the peak season (between July and October). Traders transport the crabs in plastic sacks to the depots in Subornachar, Companiganj and Feni by trawlers. They then go to Mirpur or Uttara in Dhaka to be made ready to be flown abroad in live condition. After the peak season, most of the harvesters (80%) leave Urir Char. The remainder then (during the Bangala months of Agrahayan-Falgun) harvest tortoise (not sea turtle). One person can harvest 2-10 kg tortoise per day.

The crabs are sold according to a grading system based on weight, as illustrated in the Table 5.2 (prices of 2009).

5.3 INLAND FISHERIES

Apart from the coastal fisheries, households in the new chars are also engaged in catching fish in the numerous *khal*s (streams/canals) which cross the new lands. Every household has small or large fishing traps and different nets for fishing in these internal canals during the rainy season. For households further away from the river, this is an important dimension of the fishery, while for some coastal fisher families it forms a supplement to their main occupation. In fact, this fishery does not take place only in the *khal*s. Because these are becoming shallower due to sedimentation, there is a good deal of overbank flooding at the height of the rainy season. At such times both male and female household members and children are involved in fishing when water comes to their household platform. The fish caught are mainly used for household consumption, with the surplus sold to the market. It is estimated that the average income derived from inland fishing amounts to around Tk100 per day, but total income depends on the length of the season, which varies considerably from 1-2 months to over six months in some cases.

In some larger canals, however, there is a more formal system, whereby the *khal*s are leased out in the rainy season. This system applies to three canals in Char Nangulia, the Nangulia *Khal*, the Bhuiyan *Khal* and the Katakhali *Khal* and two canals in Noler Char, the Milon *Khal* and the Hoar *Khal* and its tributaries. The leases are operated through the Union Parishad of Char Bata in Char Nangulia and Horni and Chanandi Unions in Noler Char. The lease agreements are verbal, not written. People using big nets have to pay Tk 100-500 for the entire fishing season, the amount depending on the catchment area for fishing. Other people using small fishing gears don't have to pay. The earnings from the lease of *khal*s are used for local institutional developments (mosque, schools, Madrasa etc). Local committees look after the leased *khal*s.

By 2008 the number of canals in Urir Char was rapidly decreasing due to siltation, non-excavation and encroachment. Over the previous five years half of the *khal*s were lost. Only nine were then remaining. With the approval from the Upazila Parishad, the Union Parishad leases out all *khal*s on a yearly basis through open tender. In 2008, the lease amount was Tk 127,000 taka for the four canals in the south of the island and Tk 8,000 taka for the less productive five canals in the north. The lease money is deposited to the Union Parishad's revenue account. The general population is completely prevented from fishing in or even entering the leased out *khal*s.

5.4 AQUACULTURE

5.4.1 From Capture to Culture

The transition between inland fisheries and aquaculture in a new settlement area like the new chars is complex. In fact, as noted above, the inland fishery is characterized by two elements, fishing in canals and casual catching in flooded areas outside the canals. It is virtually impossible to assess what proportion of the catch derives from each of the fisheries nor indeed from small open ponds and ditches which are used to trap fish after the flood waters have receded. These so-called "trap ponds" or ditches may be regarded as the first stage of aquaculture development (see below). They may be seen as a conscious attempt to appropriate a higher proportion of the available catch for an individual household. Many, however, are merely the result of excavation of the mud to form a house platform and trapping of fish is purely a bonus.

In fact, the movement to aquaculture in the new chars shows a steady spectrum from a ditch towards a fully developed pond in which a more intensive system may be practiced. In the new chars, just about every household has at least a ditch-like pond. At first people excavate a pond just like a ditch to raise their household platform. They use this ditch just for bathing, washing, cooking etc. After establishing a new house, they increase the size of their ditch over a period of 2-3 years, surrounding it by a dyke to create a small amount of agricultural land for *rabi* (winter) cropping and for wild fish trapping. Ponds in the new chars may be classified as follows in terms of stage of development:

Type 1: Ditches/ponds Without Dykes

This is the initial step of pond excavation in the chars. These are small ditch-like ponds without dykes, their size ranging from 4-10 decimals (Table 5.3). These ponds are not used for aquaculture but for trapping wild fish. People excavate the ditch with their own labor. This is the dominant type of pond in chars that are still maturing as Caring Char. In more developed chars, the numbers of this type are smaller.

Type 2: Ditches/ponds with Broken/incomplete Dykes

This is the second step of pond excavation in the new chars. These are small ditch-like ponds with incomplete dykes. Their size ranges from 8-15 decimals. They are always affected by tides and flood. As a consequence, again these ponds are not used for aquaculture but for trapping wild fish. The depth ranges from 4-8 feet and water is retained for about 3-4 months. After excavating such a ditch, it takes 2-3 years to develop to a semi-structured pond and then a further two-three years to develop it up to a structured pond. Local people usually raise the dykes through their own laboring. These ponds are mainly found in Patar Char-Koen Char, Char Rahman and parts of Char Nangulia. Only a few ponds have developed to this level in Caring Char.

In both of the first categories of ponds, local people are both consciously and unconsciously trapping fishes from nature. These include small indigenous species (known as Kachki), catfish (Shing, Magur), Bata, Gulla, and snakeheads (Taki, Shol). In ponds with small dykes sometimes local varieties of tilapia are collected from the upper chars and reared after the flood.

Type 3: Ditches/ponds with Crop-Land Surrounded by Dykes

This is the third step of pond excavation in the chars. This type constitutes a ditch with some agricultural land surrounded by dykes. In this category, dykes are not so high and are being raised year-by-year through household labor. These ponds are still affected by tides and flood. Depth ranges from 6-10 ft and water is retained for 4-5 months. The size range of this type of pond is between 20-50 decimals, including both the ditch and agricultural land. In these ponds, people have the opportunity for short-time fish culture, as the ponds are not so deep. Most people still stock wild fish species, but some stock carp species (rohu, silver carp, bighead and grass carp) using traditional processes. The agricultural land within the surrounding dykes is used for fish culture in the rainy season and for cultivating *rabi* crops when the water recedes to the ditches.

Type 4: Well-Defined Ponds

This type of pond is excavated with high dykes, is deeper (10-15 ft), has better water retention (6-8 months) and is not liable to flood. Some people who are financially better off can excavate such ponds in one season, using hired labor. The size of this type of pond varies from 20-50 decimals. Families are practicing extensive polyculture, without technical improvements. Over the last two years, there has been an increasing trend towards dyke raising.

The relative proportion of these different types of pond varies according to the different chars. It is clear that the less consolidated the char, the greater the proportion of relatively undeveloped ponds. Table 5.3 summarizes the general differences between these four types of pond described above.

Table 5.3 Summary Characteristics of Different Types of Ponds in the New Chars

Variables	Pond Type 1	Pond Type 2	Pond Type 3	Pond Type 4	Remarks
Dyke Status	No dykes	Broken/ incomplete dykes	Ditches/pods with crop land surrounded by dykes	Well protected dykes	Gradually raising the dyke
Range of Pond Size (decimals)	4	108	1520	5020	Annually increasing the size
Depth of Pond (range in ft)	4-6	4-8	7-10	10-15	Annually increasing depth
Water Retention Period (months)	3-4	3-5 (to October)	4-6 (to November and crop land to December	6=8 months (to February)	Very few ponds retain water all year
Culture Strategy	No stocking	No stocking.	Traditional polyculture of wild fish	Traditional carp polyculture	Technically weak
Species cultured	Wild fishes: Shol, Taki, Kachki, Bata, Koi, Shing etc	Wild fishes: Shol, Taki, Kachki, Bata, Koi, Shing etc	Wild fish and few carp species	Rui, Catla, Silver carp, Tilapia, Bighead, Grass carp, Puti	Without management
Prawn culture	No	No	No	Very few households stock prawn	Good results in prawn culture
Source of fry	No stocking	No Stocking	Upland fry traders (*Patil wala*)	Upland fry traders (*Patil wala*)	Lack of good quality fry
Feeding	No feeding	No feeding	No feeding	Little use of feed, rice bran used	
Marketing	Used for household consumption	Used for household consumption	Mainly for household consumption, some for sale	Sell to the local market; some for household consumption	Local market price low
Flooding	100% affected	100% affected	Combination of affects from rain and tidal surge (full moon, new moon)	Normally not affected	Type 4 exceptionally affected by tidal surge and flood; with improved drainage system it will be reduced.

Continued

Table 5.3 Continued

Variables	Pond Type 1	Pond Type 2	Pond Type 3	Pond Type 4	Remarks
PL Nursing	No	No	No	No	Not aware of technology
Dyke cropping	No dyke	No	*Rabi* cropping (winter) in area surrounded by dykes	Tree plantation/ cropping practiced	Good production from cropping
Objectives of Pond Excavation	Soil used for house-base upgrade. Bathing, cooking and washing	Soil used for raising house-base. Bathing, cooking and washing	Household use. Fish culture. Few ponds dig a well to keep water for a long time in the pond	Fish culture. u. Few ponds dig a well to keep water in the pond for longer.	Tendency to excavate a well in the pond to retain water

5.4.2 Aquaculture Development in the Chars

When the pond development process reaches stages 3 and 4 there is both scope and need for a more scientific development of aquaculture. With the development of the polders in the Noakhali region, there is only limited opportunity for either offshore fishing because of the greater distance of travel to the *ghats* or inland capture fisheries because of the decline in open water resources. The RFLDC Baseline study records that only 8.5% of households in the agro-ecological zone coincident with the Noakhali chars were engaged in inland fisheries in 2007, only 5.2% in PL catching and only 4.4% in offshore fishing. This was very much in contrast with the situation on the other side of the river Meghna in the Patuakhali-Barguna region, where over 30% of households were engaged in inland fisheries and 11% in PL catching.

Aquaculture in Bangladesh, particularly small-scale pond aquaculture, has taken off dramatically over the past thirty years, especially under the influence of a number of major donor-funded aquaculture development and extension projects. Supported by these projects, the Government of Bangladesh first created a network of fish hatcheries which sought to ensure the reliable supply of good quality carp seed to farmers. On-farm research and development work then identified key parameters of successful pond aquaculture: appropriate pond preparation, including preliminary fertilization, stocking with an appropriate mix of species to use the different ecological niches in the pond and at the right density, judicious feeding and fertilization during grow-out, maintenance of a good pond environment and multiple harvesting to ensure efficient utilization of pond fertility and feed.

The Department of Fisheries has been responsible for overseeing this rapid development of aquaculture in Bangladesh. However, the Department has limited resources, especially at the grass-roots where the Upazila has a technical staff of just three persons: the Upazila Fisheries Officer, the Assistant Fisheries Officer and a Field Assistant. Often one or more of these positions is unfilled. The staff has limited logistical facilities — motorcycles, computers — in the absence of foreign-aided projects. Although there have been a number of government funded projects, including one offering credit for poverty alleviation activities in aquaculture, there is tendency for such projects to be targeted towards relatively better-off farmers. The Department of Fisheries has an unclear perception on poverty focus. Thus, most aquaculture development has taken place on a project mode based on the increased resources offered by donors; in some cases, these resources are channeled through large national NGOs such as CARITAS and BRAC, both of which have their own specific fisheries programs.

Role of Danida

An important part of the early work on carp polyculture systems described above was carried out by one such donor project, the Danida-funded Mymensingh Aquaculture Extension Project (MAEP), located in the north-central part of Bangladesh. From 1989-2003, MAEP successfully raised yields in pond aquaculture in six districts in this region to around 3 metric tons per hectare equivalent.

The success of MAEP encouraged the donor, Denmark, to expand its involvement in small-scale aquaculture development to other parts of the country, especially the coastal belt on either side of the Meghna river estuary. Thus in 1997, the Patuakhali-Barguna Aquaculture Extension Project was initiated in the southern part of Barisal Division, followed in 1998 by the Greater Noakhali Aquaculture Extension Project (GNAEP). This latter project covered 15 Upazilas in the three districts of Feni, Lakshmipur and Noakhali itself. Several of these Upazilas correspond to the char lands, notably Sonagazi in Feni District, Companiganj, Subornachar, Noakhali Sadar and Hatiya in Noakhali District, and Ramgoti and Kamalnagar in Lakshmipur District. GNAEP and its successor project, the Regional Fisheries and Livestock Development Component (RFLDC), were thus the key player in the development of aquaculture in the region for a period of 15 years from 1998 to 2013. GNAEP was implemented by the Department of Fisheries and formally managed by a Project Director appointed by the Department. However, the main development role was played by the Technical Assistance staff and contracted NGOs. This situation continued in RFLDC, despite attempts to promote greater hands-on involvement of the Department.

Greater Noakhali Aquaculture Extension Project

The initial design of the Greater Noakhali Aquaculture Extension Project was strongly influenced by the experience of MAEP. It assumed that the basic technology of aquaculture was available and proposed a "massive" extension effort to disseminate this technology through regular training carried out by Field Trainers employed by contracted non-governmental organizations (NGOs). The NGOs also provided credit, on the assumption that the small farmers targeted by the project would not be able to invest in the necessary pond preparation, seed and feed for aquaculture. GNAEP effectively got under way in 2000 with the contracting of the first NGO and expanded its program in 2002 with the hire of three other NGOs. Through this training and credit approach to extension, yields of carp polyculture in ponds were raised from around 1,200 kgs per hectare equivalent to around 3 metric tons, similar to those in MAEP.

Promotion of Pro-poor Aquaculture: However, the translation of the MAEP model to Noakhali was not entirely successful. As GNAEP developed, it became apparent that the standard carp polyculture system was not suitable to all contexts and that the link with credit provision tended to reduce the attention paid by the NGOs to follow-up activities. This link tended also to attract better-off farmers seeking a source of cheap credit. It also became clear that carp polyculture was a relatively low return system, which did not contribute in a major way to lift poorer farmers out of poverty. Thus, from 2002, GNAEP began to explore a more overtly pro-poor approach, focusing on the needs of resource-poor farmers and seeking to identify aquaculture interventions which would fit into their resource systems. This concentration on the resource-poor inevitably led to a greater degree of focus on the Noakhali char lands.

From 2002 GNAEP identified several possibilities for different aquaculture development systems for poorer people. These included:

- Introduction of integrated rice-fish-freshwater prawn culture (Integrated Prawn Farming, IPF) in paddy fields in the chars, known in Bangladesh as *gher* farming, a system which had originally been introduced into paddy fields in the southwest by the farmers themselves and promoted by the NGO CARE. This was not the culture of brackish water shrimp (Bagda) about which, in the early part of the 2000s, there had been considerable controversy about the environmental and social impacts of the expansion of larger holdings in southwest Bangladesh leading to salinity intrusion on paddy lands and displacement of poor farmers.
- Development of improved aquaculture in community ponds in cluster settlement villages developed under CDSP as well as development of carp and prawn nurseries in small-seasonal ponds developed by poor households from raising the homestead platform in areas subject to flooding.
- Apart from the pro-poor interventions focused on aquaculture, GNAEP also attempted to improve the livelihood of the women fish driers in Hatiya, mentioned in section 5.2.1 above. This involved releasing the chewa fishers

from *dadun* by offering loans through newly established Fishers Associations and a guaranteed market in the prawn system in return for guarantees not to use pesticide in the fish drying. Under this arrangement the price of chewa received by the communities increased considerably.

- Cage culture in rivers and in multiple ownership ponds.
- Aquaculture in the rainy season in waterlogged paddy lands in the northern part of Noakhali.

Apart from the last two, these new systems were mainly oriented towards the char lands. Indeed, the Integrated Prawn Farming systems in paddy fields were specifically piloted amongst 400 households in poor communities in the chars in Companiganj, Noakhali Sardar (now Kabirhat Upazila) and Ramgoti.

GNAEP had considerable initial success in promoting these pro-poor interventions. In particular the specific intervention of nursing of prawn post-larvae (PL) in micro ponds owned by women headed households in Subornachar Upazila often enabled the women to rear two cycles of PL over a six month period with a profit of around Tk 8,000-10,000. Although the deep cluster village ponds appeared not to be an ideal culture environment for prawn, GNAEP also established that they were capable of producing very large size prawn, able to be sold at the pond bank at around Tk 600 per kg (US$8-9 per kg). Thus, a typical cluster village pond of around 1 acre produced returns of up to Tk 200,000 to be shared between the 25 surrounding households.

GNAEP's success in widening the aquaculture options and increasing the value-added from the limited aquatic resource systems of small-scale farmers, was not only based on the technical interventions. Given the pro-poor emphasis, GNAEP adopted a more participatory approach to its farmer training. Supported by the recruitment of staff from CARE, Bangladesh, who had experience in the experiential learning approach known as the Farmer Field School, GNAEP adopted a participatory learning approach to the training of farmers in integrated prawn farming. This involved recruitment of young facilitators to work with the farmers and the design of a number of learning sessions, both for men in aquaculture and for women in dyke cropping.

Role of the Private Sector: The new approach also depended upon development of the wider support system. Supplies of quality prawn seed were ensured through the promotion of and technical assistance to private sector hatcheries. Hatchery development was envisaged in the original design of GNAEP, but centered on the Raipur Hatchery and Training Centre of the Department of Fisheries. The shift to private sector investment not only served to save project financial resources, but also to create one of the biggest concentrations of prawn seed production in the country. The level of efficiency achieved in these hatcheries enabled sale of post-larvae at a price of Tk 1.25 per piece from 2002 to the end of GNAEP in 2006, only half the prevailing price offered by the hitherto dominant hatcheries run by BRAC. It was this competitive price for post larvae, constituting around 40% of the production costs of prawn culture, that enabled many resource-poor farmers in the Noakhali chars and elsewhere to invest in the system. Alongside the hatcheries, GNAEP encouraged local entrepreneurs to invest in a small feed mill and, with support from the Embassy of Denmark's Business-to-Business (B2B) Development Program, a modern fish and prawn processing plant in the region. Altogether these private sector investments totaled over Tk. 200 million.

Promotion of Farmers' Organizations: The other key element of the support system was the development of community-based organizations (CBOs). When the prawn farmers emerged from the extension process, they were asked how they would be able to sustain the aquaculture system. Most replied that they needed a continuing source of information and quality input supply, the answer to which appeared to be some form of farmer organization. Thus the post larvae, feed and other input supplies required for prawn farming were channeled to the farmers through the development of a network of CBOs managed by groups of farmers, which acted as the agents of the hatcheries and the collaborating local feed miller. The CBOs took the orders from farmers and were given a commission by the private sector partners, which allowed them to expand services in other directions, in both the economic and social spheres. Originally established in the integrated prawn farming piloting areas, the CBOs rapidly expanded to the fish farmer groups in the pond polyculture areas. Observing the success of *gher* farming, these groups also added prawn farming to their culture system.

Regional Fisheries and Livestock Development Component: Expansion of the Model

Farmer Field Schools as the Training Mode: Although its duration was extended somewhat, GNAEP ended in September 2006 to be replaced by a more integrated project linking GNAEP with a livestock extension component (see Chapter 6) into the Regional Fisheries and Livestock Development Project, Noakhali Component (RFLDC, Noakhali). Although widened in scope, the design and focus of RFLDC continued to follow the approach begun under GNAEP. In particular the participatory learning approach developed under GNAEP came into play as the standard training mode. RFLDC was a part of Danida's Agricultural Sector Program Support, Phase II (ASPS II). Under earlier phases of this program, the Farmer Field School (FFS) approach was promoted in successive projects of the Department of Agricultural Extension's Integrated Pest Management program. Over time it became the preferred training mode for the whole of ASPS II, including RFLDC. For RFLDC, Noakhali an initial target was set for 5,100 FFS in its 5-year implementation period. The RFLDC FFSs were integrated in scope, covering both fisheries and livestock and also included homestead gardening and nutrition issues. They were demand-driven in the sense that the curriculum was flexible according to the needs of the farmers.

The Farmer Field School approach is a highly participatory mode of training in which groups of farmers identify what they wish to learn. The farmers undergo a process of discovery in which they identify their resources, exchange their own experiences in the best use of those resources, carry out experiments to compare possible new technologies and make their own decisions on adoption. There is no credit line so that farmers join the FFS because they want to learn and adopt innovations consistent with their financial ability.

In RFLDC, aquaculture was just one module in the Farmer Field School. Through 5-6 Learning Sessions conducted over a whole culture season, farmers analyzed the potentials of their aquatic resource systems, whether household or community-based, and determined through exchange of experience and on-system trials what technologies were suitable for them. Inevitably these Learning Sessions incorporated such issues as pond preparation, choice of suitable culture species and stocking densities, feed and fertilization, good husbandry, avoidance of risks and harvesting– and marketing strategies.

The Farmer Field Schools were conducted by young men and women — almost 50% of the total were women — chosen from farming households in the local community for their communication skills and social acceptance. These young people, known as Local Facilitators, were trained by Project staff in a four-month so-called "Season-long Learning" in which they learned how to run a Field School. They developed facilitation skills and received hands-on practice in the various technical issues to be discussed in the FFS. On this basis, they passed on their experience to the farmers. Given their often limited educational qualifications and farming background, it was expected that the Local Facilitators would stay in the community and practice themselves the new techniques discussed with the farmers.

Widening of the CBOs' services: Most of the Farmer Field Schools were also organized by the CBOs, which ensured the provision of services to support the FFS learning. Under RFLDC, the training through FFS was thus complemented in the provision of services once again by promotion of Community-based Organizations, many of them inherited from GNAEP. The CBOs in turn received support through links to private agribusiness and by a Block Grant facility offered to local government institutions. The CBOs were able to tap this facility for making further investments. Thus, in the aquaculture sector, the CBOs established nurseries for fish and prawn to ensure that the seed of the right size could reach their members and clients in a timely manner (Table 5.4, Main Activities).

Table 5.4 Details of CBOs Close to CDSP IV

Name	Union	Founded	#FFS	LF	PW	CLW	CAA-RP	Cash-ier	Funds	Main Activities	CDSP	Coop
Satota BUS	Char Jubilee	Jan-04	34	5	1	1	2		943,600	Vaccination, prawn nursery, cap nursery, seine net, duckling production, Red Chittagong Bull, milk PMG,		
Meghna BUS	Char Jubilee	Jan-05	26	3	1	1			302,480	Silver carp nursery, duck PMG, vegetable, banana, soyabean PMG		
Digonto BUS	Char Jabber	July-04	30	4	1	1	1		828,715	Vaccination and deworming, carp nursery, PL nursery, SRT nursery, vaccine sub-center, duckling production		
Char Jubilee Upakulio Sommany Parishad	Char Jubilee	Apr-08	8	1		1			106,564	Vaccination, Credit-in-kind to CV pond		SWD
Char Jabber Upakulio SK Parishad	Char Jabber	Apr-08							113,000	Duckling production,. Vaccination Support to fish farmers		
Char Lakshmi Jano Kalyan Sangstha	Mohammed-pur	Nov-11	12	2	1	1			171,500	Ducklings, Vaccination		
Bangla Bazar Upakulio BUS	Char Clerk	Jul-04	46	6	1	1	1		1,127,150	Fish Farming Group, Goat Kid, Duckling, Egg Marketing		
Saikat BUS	East Char Bata	Jan-05	33	6	3	3			1,054,970	Community aquaculture, Juvenile PMG, Carp PMG, Cast net making, tilapia PMG, duckling production, chick production, vaccination, DOD via RHH		
Ashrayon BUS	East Char Bata	Nov-09	?	10	1	1			875,383	Community-based aqaculture. Net making, PL supply		
Bangla Bazar SUS	Chanandi	Feb-10			1	2			246,350	Vaccination, duckling production, SRT nursery, pigeon PMG		

Continued

Table 5.4 Continued

Name	Union	Founded	#FFS	LF	PW	CLW	CAA-RP	Cash-ier	Funds	Main Activities	CDSP	Coop
Jagarini SUS	Chanandi (eastern part)	Dec-12	None		2	1			123,600	Vaccination, Pigeon PMG, fish and cattle feed		
Janata SUS	Chanandi	Dec-08	29	4	1	1			520,540	Duckling production, goat kid production, milk and curd PMG, egg producer PMG		
Progoti SUS	Chanandi	Feb-10			1	1			241,290	Vaccination, duckling production, SRT nursery		
Karim Pani BSD Ltd	Mohammed-pur, Char Alauddin	Jun-07	20	3	2	1		2	778,596	Polyculture in CV, Carp nursery. PL nursery, Vaccination	Yes	Yes
Char Torab Ali MKUS	Mohammed-pur	Aug-06	28	4	2	1			578,578	Lamb production, Ducklings, Milk PMG, Polyculture in Ashrayon, Carp PMH, Beef Fattening		
Adarsha Nagar Samaj US	Char Fakira	Apr-03	40	2	1	1		1	818,245	Milk PMG, Vaccination, AI		
Bamni No.1 WMCA	Char Elahi	Jan-06	10	2	1	1			147,026	Egg PMG	Yes	Yes
Musapur Jubo US	Musapur	Jan-09	19	3	1	1		1	639,600	Day-old Ducklings, goat and sheep, Fish culture in Ashrayon		
Char Elahi Nari Kalyan Sangshta	Char Elahi	Jun-06	20	2	1	1			517,967	Egg PMG		Yes
Char Kalmi Jubo US	Gangchil/ Elahi	Dec-10	15	3	1	1		1	492,453	Day-old Ducklings, Papaya PMG, Ricksha Van; IDE Project		
			210	37	14	11	1	5	6,270,098		2	3

Notes: FFS = Farmer Field Schools, LF = Local Facilitators, PW =Poultry Workers; CLW = Community Livestock Workers; CAARP = Community Agriculture and Aquaculture Resources Persons; PMG = Producer and Marketing Groups; SRT = Sex-reversal Tilapia; RHH = Rice-husk duckling hatchery; DOD = Day-old Ducklings; PL = Prawn post-larvae; CV= Cluster Village, AI = Artificial Insemination; Funds in Takas; The BUS, SUS, etc in the name of the CBOs are the abbreviation of the extended name in Bangala.

Table 5.4 also points to the fact that RFLDC also trained Community Agriculture and Aquaculture Resource Persons (CAARP) in the CBOs through a similar practical Season-long Learning to manage the nursery facilities and to act as the key focal point person in the organization to interact with the hatcheries and other input suppliers. The CBOs were clustered in District Associations which also made links on their behalf to private agribusiness. The Feni District CBO Association for example, commissioned a local miller to produce fish feed according to a formula set by the Association, which was then distributed through the CBOs.

As Table 5.4 shows, the nurseries included not only carp and prawn, but also tilapia. RFLDC recognized that in the chars in particular, there was only a short culture season for aquaculture. This is the case either because of late rains or because the water table drops rapidly in December-January. Thus, Indian major carps, which require a longer growing season, are not ideal species in this context and prawn also only grows to a small size in the 5-6 months when water is available.

The initial success of prawn culture in paddy fields was based on extremely favorable conditions in 2002-3 and proved more difficult to sustain in the years following because of drought and flood. Moreover, although at the end of GNAEP, some 6,000-7,000 households were engaged in the prawn value chain, this proved to be the peak of its expansion. Increased demand for prawn post-larvae led the hatcheries to turn to purchase of brood stock from culture systems in Bagerhat, compromising on seed quality. RFLDC addressed this problem in a joint adaptive research project between the Upakul Freshwater Prawn Hatchery and Bangladesh Agricultural University, aimed at developing quality brood from juveniles reared locally in the Noakhali chars. This project was successful in producing brood stock of the fecundity and quality if wild brood from the Halda River but the results could not be fully implemented before the end of the Project.

Indeed, while it was under way, in 2009-2011, and despite the efforts in GNAEP and RFLDC to promote low-input production systems ensuring "clean and green" production, free of contaminants, lack of a national certification-traceability system for shrimp and prawn exports led to rejections of shipments in the European Union because of antibiotic contamination. This forced the Bangladesh Frozen Food Exporters Association to impose its own ban on further shipments and badly affected the operations of the Noakhali hatcheries, damaged farmer confidence and forced an increase in seed prices.

It was in part response, therefore, that RFLDC began to encourage alternative culture systems, notably inserting tilapia, which was growing in popularity in local market and commanded a good price, into the polyculture. RFLDC had conducted a series of on-farm trials to determine whether tilapia could be reared successfully in the carp-prawn polyculture. This had been established elsewhere, but there had traditionally been resistance to tilapia culture in Bangladesh because of its exotic status. Based on this experience, another local entrepreneur was persuaded to develop a tilapia hatchery in the chars, utilizing sex-reversal techniques which ensure all male fish which grow rapidly in appropriately fertilized ponds.

Improving Fish Seed Quality: RFLDC also engaged with private agribusiness in attempting to improve the quality of carp seed. Deterioration of seed quality of Indian major carps through interbreeding and uncontrolled hybridization between the three species of Indian major carp, rohu, catla and mrigal, had been recognized increasingly by researchers — also by farmers — as a major constraint on improvement of the productivity and profitability in aquaculture. Although the Department of Fisheries had begun the development of pure breeding stocks at major seed production centres such as Raipur, the problem was also to change the management system of private sector hatcheries, which supply over 95% of fish seed to farmers, in order to ensure that improved seed indeed reached the farmers.

Thus, one of the features of the last three years of RFLDC was its attempt to address the major problem of the declining quality of fish seed in Bangladesh caused by interbreeding and uncontrolled hybridization of the brood stock in the private fish hatcheries. In co-operation with the World Fish Center, Bangladesh and South Asia Office, RFLDC built a network in the Noakhali region to introduce improved hatchery management practices to a number of private hatcheries. This started with improvements in physical infrastructure and brood stock management of Indian Major Carps and continued in 2012-13 with introduction of improved strains of mainly of rohu and silver barb and the expansion of the breeding system/protocols for tilapia hatcheries. A breeding nucleus for improved carp seed was established at the (private) Karnafuly Hatchery in Raipur Upazila of Lakshmipur District, while three other private hatcheries obtained improved brood stock. A similar system for tilapia was based around the Green Field Breeding Nucleus in Lakshmipur and improved brood stock of 14th Generation GIFT tilapia was made available also at three other hatcheries.

5.4.3 Potentials for Aquaculture Development in the Chars

There is a considerable potential for the development of aquaculture in the Noakhali chars. Based upon the RFLDC Baseline Survey conducted in 2007, 43.5% of all households in Project's service area had an aquaculture production system, almost all of them household ponds. In the area which covers the Noakhali chars, this proportion increased to 58.1%, among which a very small proportion are rice field culture systems (ghers). A typical pond in this area was 26.1 decimals or just over 1,000 square meters. Such systems were mainly under a carp polyculture of catla, rohu and mrigal, although in some cases there was a movement to stocking of tilapia. Typical stocking densities are 1.5 fry per square meter of pond surface. In the new chars, as we have seen, apart from the conversion of former trap ponds to aquaculture after the protection of the chars, the very process of embankment of the chars and the raising of road embankments creates borrow pits which can also be developed into relatively large fish ponds, albeit by some of the better-off households. Another relatively recent development (since 2013) has been the promotion of "integrated agriculture" under the "sorjon" system by the Department of Agricultural Extension in the chars. This involves the conversion of paddy fields into "ridge and furrow" systems in which vegetables are grown on the ridges and fish cultured in the trenches. It is estimated that maybe 5% of households may have converted to this practice.

General Profile of Aquaculture in the "New Chars"

Over the five years since the Feasibility Studies of the new chars, the situation changed considerably, with more and more ponds being developed into categories 3 and 4 as the wild fishery declined. According to the CDSP IV Draft Baseline Survey, 92% of households in the Project area have at least one pond or ditch. Of these, 51% are actually practicing fish culture (Table 5.3). In Caring Char, the proportion of households with ponds is less and the numbers of households culturing falls to just 25%. These figures were more or less confirmed by the Agricultural Benchmark Survey, which also recorded that 93% of ponds are within the homestead area. Average pond size varied from between 15 to 28 decimals (600 to 1120 square meters according to zone, except for Urir Char, where the average size was 72 decimals (2,880 square meters). This is explained by the fact that the ponds in Urir Char were excavated during the land accretion period by erecting small dykes across areas of low-lying land.

In this context, aquaculture practices in the CDSP IV area are of two types. Most households — especially the resource poor women members of the NGO groups — are culturing following traditional practices ("extensive" in the conventional aquaculture development terminology) (Table 5.5). 75% of those culturing their ponds only stock and harvest with no feeding or fertilization, largely because of the high risk posed by flooding from tidal surge or waterlogging during the monsoon or from the limited period of water retention, especially in parts of Char Ziauddin and Char Nangulia. It is interesting to note that the species of fish most frequently stocked are tilapia (over 80% of households), grass carp and silver carp (over 70%), which is rather different from the dominant culture of Indian major carp (rohu, catla and mrigal) in Bangladesh (Figure 5.3). In 2013, in field interviews carried out by the writer with the poor women members of the NGO Credit and Savings Groups, it was explained that the tilapia stocked was the normal breeding fry rather than the sex-reversal tilapia (SRT), derived from fry treated with methyl-testosterone which is spreading widely in Bangladesh and especially in the Greater Comilla region. This was because the non-SRT fry were available cheaply as "swim-up fry" from local ponds, the owners of which sometimes advertised their availability by "miking". Interestingly the same reasons of easy availability were given by the rather better-off male majority members of the Farmers' Forums, with more developed ponds, who might well have benefited from the SRT fry. The prevalence of stocking grass carp was explained in rather similar terms, namely that the fish grew quickly on a diet of grasses cut from the wild and thus were also a low cost investment.

It is worth observing in Table 5.5 that only in the relatively more isolated context of Urir Char do the households culturing fish face problems with supply of fingerlings. Almost all of these are obtained from local vendors (*patil wala*s), although it may be that the choice and quality of the fingerlings poses a problem.

Only relatively few farmers, among the leadership of the Water Management Groups (and CBOs inherited from RFLDC), were seeking to culture in a rather more intensive manner. In this case and with reference to tilapia there was interest in culturing the mono-sex type of tilapia with a view to sale in local markets. This had been encouraged also by an initiative taken under the Support to Agricultural Research for Climate Change Adaptation in Bangladesh (SARCCAB) project which had been conducting agronomic research in the CDSP area and which had formed an alliance with the NGO Shisuk based in the Daudkandi area of Comilla District. Shisuk had promoted the use of improved quality seed through the WMG in the area, with a partial subsidy, probably with a view to encouraging sales from their associated hatcheries.

Table 5.5 Characteristics of Fish Culture by Char

	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
HH culture pond/ditch (%)	47	62	42	25	84	51
Type of culture (%)						
Traditional	81	80	82	53	54	75
Semi-intensive	16	19	18	47	43	24
Intensive	2	1	0	0	3	1
If not cultured why? (%)						
Flooded during high tide	55	67	86	82	62	75
Lack of fingerling and other inputs	6	0	0	0	13	1
Risk of theft	8	1	1	0	6	1
Low water retention	31	32	13	18	19	23

Source: CDSP IV, Draft Baseline Survey.

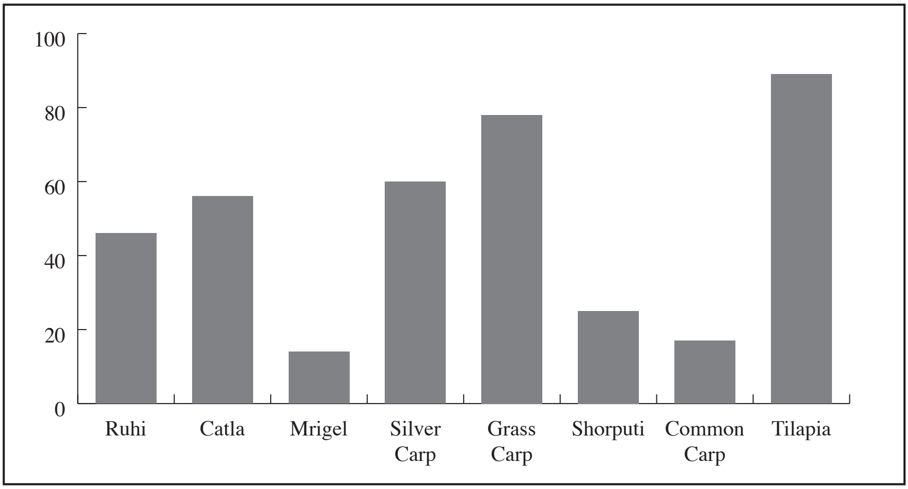

Figure 5.3: Stocked Species

Despite the presence of GNAEP/RFLDC in the more consolidated area of the chars for several years, according to the CDSP IV Baseline Survey, yields are very low in the study area, (1.74 kg/decimal), far below the national average (Table 5.6).

The highest average yield is in Char Ziauddin, 2.8 kg/decimal, the least isolated area and the area probably most exposed to previous extension activity (see below), and the lowest in Noler Char, only 1 kg/decimal. More than 67% of total production from ponds/ditches is used for household consumption. Per household income from the pond is Taka 4.515. However, in Urir Char the per household income is around double that in the other chars, due to the average bigger size of pond/ditch there.

Table 5.6 Fish Production and Consumption

	Char Ziauddin (n=43)	Char Nangulia (n=362)	Noler Char (n=115)	Caring Char (n=62)	Urir Char (n=81)	All (n=663)
Average Production (kg/HH)	37	43	25	30	89	43
Production (kg/dec.)	2.8	1.8	1.0	1.9	2.0	1.74
Average Consumption (kg/HH)	28	29	20	25	52	29
Average income from pond (Tk/HH)	4070	4730	2750	3000	8900	4515

Source: CDSP IV, Draft Baseline Survey Report, February 2012.

Indeed, the average yield in these systems, was actually less than the 2007 RFLDC Baseline, which was still low at just 5kg per decimal (1,250 kg per hectare). Of this 0.4 kg constituted freshwater prawn. Sales of fish per decimal were 3.8 kgs, including 0.3 kgs of prawn. Total income from the pond systems, excluding prawn, averaged Tk7,552 per household in 2006-7. These yields were already low considering the fact that over 80% of pond culture systems in the RFLDC Baseline which covered much more developed areas in the whole region, applied supplementary feeds, mainly oil cake and wheat bran, and over 60% applied urea fertilizer and/or cow dung. However, amounts of feed were small; the average application of organic fertilizer use per household was a mere 11 kgs, mainly on a bi-monthly basis. There thus remains substantial scope for raising productivity to the levels achieved in the wider area of GNAEP and in the Mymensingh Aquaculture Extension Project.

Increasing Productivity Through Improved Seed Quality

It is considered that aquaculture productivity can be improved most cost effectively in the short term by improvements in the quality of fish seed as discussed above. The improved hatchery most relevant to the tilapia-based systems emerging in and nearest to the Noakhali chars is the Bismillah Agro Production (BAP) complex close to Noakhali Science and Technology University. This hatchery is owned by a young agricultural graduate who won a national award in 2012 for his vision and success in developing his integrated farm. He was trained at the Central Luzon State University in the Philippines and was well regarded by the World Fish Center experts for his willingness to adhere to the hatchery management protocols for tilapia. His farm was designated as a Satellite Centre under the RFLDC-WFC project of cooperation, taking improved brood fish from the Breeding Nucleus at Lakshmipur and multiplying these for sale of brood fish to other hatcheries. The farm also sold fingerlings to grow-out farms. Having seen the operation of the Greenfield Hatchery in Lakshmipur, the owner had ambition to develop his hatchery as a Breeding Nucleus so that he would have several strings to his business bow and maintain the quality of his own brood stock.

In 2013, BAP produced 10 million tilapia fingerlings; 100,000 of these were sold as brood fish to other hatcheries, including at the Sylhet Agricultural University. The remainder were sold at 30 days old to other farmers in various parts of Bangladesh. At least 3.5 million fingerlings were sold in the Noakhali area, chiefly to a group of 500 farmers recruited by the hatchery itself, many of them in the Noakhali chars. A few went to selected CBOs, including 15,000 to the Tankhir *Khal* WMG/CBO in Boyar Char. The hatchery offered training to these farmers, partly through a group of four "volunteers" operating on the basis of a lump sum honorarium a little like the Local Facilitators of RFLDC.

One month old sex-reversal tilapia under this private sector extension program were sold at Tk 0.60 per piece, with a 5% discount being given to the volunteers/facilitators, so that they obtain a profit of Tk 0.03 per piece. Delivery of 50,000 seed was free and an extra 5% of fingerlings was given against mortality. The hatchery owner said the experience had been positive so that his target production for 2014 was 25 million month-old fingerlings.

Most of the fingerlings sold were sex-reversal, but 500,000 (10 tonnes) were distributed as normal non-sex-reversal tilapia. These were sold at 1 inch size at 30-days for Tk 0.40-45 per piece.

Observing the growing importance of tilapia in the new chars, the owner of BAP had positive interest in the possibility of expanding his market into the CDSP IV Project region as a contribution to marketing of his increased targeted production in 2014. He noted that there was another tilapia hatchery closer to the new chars in the area of Char Wapda, but this hatchery did not offer improved quality seed and was perceived to be losing market. Importantly in terms of the description above, he declared he would be willing to supply both normal (non-sex-reversal) and sex-reversal fry and offer training either through his own extension system or in co-operation with the Upazila Fisheries Office, with whom he had already been co-operating. Part of the training focus would be nurseries at the WMG/CBO level, since sale of one-month fingerlings would probably require a further six week nursing period before transfer to grow-out system.

The hatchery owner also had some stocks of some of the other species which are in increasing demand in the chars, such as grass carp and Thai Sharputi (silver barb). In 2013 he produced himself 150,000 Thai Sharputi from stock distributed in the RFLDC-WFC network. He was also the President of the newly formed Noakhali Agribusiness Association (NABA), a group of eight private sector agricultural entrepreneurs including the Upakul Prawn Hatchery. He felt that he could facilitate the supply of quality seed of other species such as grass carp, rohu and Thai Sharputi either by drawing the other hatcheries in the World Fish Center network into NABA or simply by contacting those other hatcheries with whom he had close relations and acting as “middleman” for the Noakhali char area.

5.4.4 Exit Strategy of RFLDC: Attempts At Integration of Aquaculture and Livestock Into CDSP

The design of RFLDC was meant to address the limitations of the earlier extension approach, particularly its rather rigid technology-driven mode and the limited emphasis on sustainability. The strategies for development of Farmer Field Schools through Local Facilitators, developing CBOs and developing the links of these organizations with private agribusiness had always been seen by RFLDC as a means to maintain a sustainable extension system at the end of what inevitably would be a time-bound project. Importantly, the FFS curricula were designed with a degree of flexibility so that the participants learned to adapt the technologies to particular environmental contexts.

This may also be seen as important in the context of climate change. A variety of factors are likely to affect aquaculture in the coastal zones: higher sea levels causing drainage impediment, greater salinity intrusion, changes in the pattern of rainfall causing longer dry seasons and more intense rainfall in the monsoon season, changes in land and water temperature. Although most species currently being cultured are reasonably tolerant of changes in water temperatures, there may be need to adjust the species mix in relation to salinity, while flooding and waterlogging may require adjustments in pond design and a shift from individual household culture systems to community-based systems over time, similar to what has taken place in the areas of impeded drainage in the northern part of the Noakhali region.

The technical learning in the FFS was supported by inputs supplied through the CBOs. In Subornachar Upazila, the heart of the Noakhali chars, by 2013, there was a network of 18 CBOs, the number of which increased as Farmer Field Schools were implemented in more isolated areas and formed their own farmer organizations. Most of them were members of the umbrella South Noakhali CBO Association (SNCA). As Table 5.4 has shown, some of them were based upon and involved in widening out the activities of Water Management Groups established by CDSP. Most of these then conducted their own FFS. A similar network of 32 CBOs was established in Hatiya Upazila under the Hatiya CBO Association (HCA). In other cases, RFLDC enlisted the services of local NGOs to conduct FFS with the same budget for each FFS as that offered to the CBOs. In Noler Char, Sagorika Samaj Unnayan Songshta initially conducted 50 FFS and started a further round of 30 FFS. In Char Nangulia, Upakul Unnayan Songstha began a similar process with 18 FFS.

Despite the positive achievements of RFLDC, Noakhali, towards a sustainable extension system, because of wider policy considerations in Danida and disagreements between the Embassy of Denmark and the Ministry of Fisheries and Livestock, the fisheries and livestock components of ASPS II were not extended into a further phase after June 2013.

In these circumstances, the close relationship between RFLDC and CDSP IV discussed in the preceding paragraphs ensured that there was a smooth exit strategy at least in the coastal chars. Based on the recommendations of the retiring Senior Advisor of RFLDC, Noakhali, CDSP IV appointed new technical specialists for aquaculture (and livestock, see Chapter 6) development and expanded the services available to the sector through the CBOs and the range of field level institutions which had been organized by CDSP. In the aquaculture sector, there was an obvious link to Water Management Groups (WMG). As an example, the Al Amin WMG in Noler Char developed a fish pond for the production of fish fingerlings under CDSP introduced by the NGO Shisuk as part of the co-operation with the IFAD-funded

SARCCAB in which they had invested Tk 30,000 and already gained a profit of Tk 50,000. This was extended by the 11 WMG in Char Nangulia which collected a total of Tk 300,000 for lease of a large area of pond at Chobbih Dag Samaj and again had already started to sell fish. Three WMG close to the Kaludar Bazar CDSP Site Office, Bhuiyar *Khal* WMG, Nonar *Khal* WMG and South Nangulia WMG had bank balances derived from savings and investment of Tk 70,000, Tk 60,000 and Tk 60,000 respectively. Two represented at Haji Idris Bazar in the northern part of Char Nangulia (North Katakhali *Khal* #1 and #2 had balances of Tk 50,000 and Tk 38,000 respectively, including Tk 8,000 from the initial returns from the Shisuk Project.

However, it proved to be more difficult to integrate the capacity building dimension of RFLDC into CDSP since livelihood development training under the latter was carried out either by the Department of Agricultural Extension through Farmers Forums, a different mode to the Farmer Field School. Training in the homestead agriculture sector was through the contracted NGOs which at least initially focused on livestock rearing and homestead gardening through conventional short duration (2-3 day) training modules for their credit and savings groups.

5.5 CONCLUSIONS

The experience of fisheries and aquaculture for livelihood of the settlers in the costal chars of Noakhali described in the above paragraphs may be summarized in the following points.

Pressures on Wild Fisheries

Fisheries has traditionally been a major source of livelihood in the Noakhali chars. Many of the settlers in the area were previously involved in inshore fishing in the Hatiya channel and elsewhere. Offshore fishing remains a significant source of livelihood for a significant minority of households in the outer reaches of the chars, but it is under pressure for a variety of reasons, such as environmental changes related to the siltation of the estuary, overfishing as a result of the increased number of households engaged in the industry and, increasingly, government restrictions on catching of juvenile hilsa and shrimp and prawn post-larvae in order to conserve these resources. Climate change may also be having an effect on the fishery, initially through the increased incidence of stormy weather which restricts the frequency with which the fishers are able to move to the sea. The net result of these pressures is a decrease in catches and loss of livelihood.

Potential of Aquaculture in Chars

Although some fishers are able initially to compensate for the loss of the offshore fishery by trapping and fishing in the riverine tracts and creeks of the new, as yet unprotected chars, siltation is also affecting these resources. Projects for the stabilization and embanking of these chars which block the water courses and restrict the movement of the wild fish, inevitably lead to further decline in the inland fishery just as has happened in the existing protected chars.

In these circumstances, aquaculture development is required. This has begun to take off in the more stable and protected chars, but productivity and returns remain low. There are considerable potentials for increasing the contribution of aquaculture to livelihood, but to realize these potentials in the Noakhali chars three key issues must be addressed: appropriate technical interventions; the institutional basis for intervention; and secure land tenure. There is a need to recognize that not all parts of the new chars are ready for aquaculture, that the wild fishery still represents an important if not properly quantified resource. In some cases, at least in the first instance, the best intervention may be to try and maintain the wild fishery, especially the freshwater sector, assuming that this is accessible to all or can be managed on an equitable basis, possibly under CBO management.

Appropriate Interventions and Institutional Framework

In other contexts, there are clearly potentials for aquaculture development, in household ponds and in the various community ponds and borrow pits that have been created by projects like the Char Development and Settlement Project and by government resettlement schemes. For these potentials to be realized, the suitable technical interventions have got to be established, based upon the resource potentials, size of culture systems, length of culture season and the availability of the necessary inputs, especially quality seed. Moreover, these inputs have got to reach the farmer in a regular and timely manner, requiring an appropriate and sustainable institutional framework.

Issues of Prawn Culture and the International Market

The development of aquaculture in the chars was facilitated by two well-resourced donor-funded projects, GNAEP and RFLDC, both in terms of finance and skilled technical assistance over a period of more than a decade. These Projects were able to create integrated systems involving innovative technical interventions and institutional support. Effectively, the Projects created and controlled the system at the grass-roots level. However, as the example of the prawn industry described above shows vividly, however hard they try, such Projects cannot control all the key factors for success especially where the production and sale is to wider markets. International market regulations and the lack of a national certification system for aquaculture, especially shrimp and prawn exports, undermined the Projects' efforts in the longer-term, ultimately affecting the livelihood of the rural poor.

Security of Land and Water Tenure

As with most agricultural investments, farmers must be assured of their tenure over land and water resources if they are going to make the necessary investments. With regard to the first two factors, the strategy adopted by RFLDC in introducing appropriate technical improvements through the Farmer Field School approach and provision of inputs and services through promotion of community-based farmers' organizations was generally promising. In relation to the third factor, in the Noakhali chars, RFLDC depends upon the efforts of complementary projects with a different focus like CDSP to ensure the appropriate land and water rights. The land settlement component of CDSP is a good example.

Operations and Maintenance and Climate Change

Finally, reference has been made briefly in the text above of the importance of adaptation of the technical interventions in aquaculture to the growing threat of climate change. Emphasis has also been given to the fact that the transition from capture of wild fish to productive aquaculture depends upon the protection of the agricultural land by well-constructed and well-maintained sea dykes. Without such protection, the necessary investment in aquaculture will not be made.

This latter point was brought home vividly to this writer in 2016 during a visit to the successive CDSP areas in Noakhali in assessment of levels of food security. It became clear that the remaining unprotected areas were much less food secure than those behind the dykes. More importantly, however, it was seen also that two parts of the CDSP target area which had been protected by other projects were no longer secure because of dyke erosion and outright destruction. Once the dykes were breached, the areas behind which had developed a relative prosperous agricultural system including diversified cropping and pond culture of tilapia, were once again vulnerable. On a visit to Companiganj during this mission, the writer was confronted by a farmer whose fish pond dyke had been eroded by the tidal surge cause by a modest cyclone the previous day. He estimated his losses to be well over Tk100,000 and had brought his land title deed along perhaps in the hope of compensation. He and his neighbors had effectively reverted from a Type 4 pond under the classification above to a Type 1 or 2 pond as the problem had intensified and not addressed by the authorities. Later in the same visit the newly constructed dyke on the eastern side of Char Nangulia suffered a similar rupture affecting the investment behind it.

It is difficult to attribute these events to climate change, but the Meghna Estuary remains a highly dynamic hydrological system in which the erosive flows are regularly changing and quite possibly increasing in strength, so that the need for careful and vigilant maintenance (O and M) of protective structures is becoming urgent. In its absence, the other factors of climate change, tidal surges and salinization of agricultural lands will become all the more damaging to livelihood.

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Chapter 6

Animal Husbandry in Livelihoods in the Chars

Dr. Harvey Demaine

6.1 INTRODUCTION: LIVESTOCK REARING AS A COPING STRATEGY

In the previous chapter, it was noted that for a large number of the settlers in the Noakhali chars fishing in the Meghna estuary was their original occupation. In that sense the shift from inshore fishing to inland capture fisheries to aquaculture we have described appears a rather natural transition. The same is not true of livestock rearing, which has been taken up as an alternative livelihood strategy in response to the opportunities offered as the in-migrants have settled. Indeed, there appear to be some constraints to livestock rearing at the earliest stages of char land settlement. It is only when the char is sufficiently consolidated that it can be colonized by grassland vegetation which then offers the opportunity for livestock grazing. At this point livestock becomes a crucial part of the household economy, as a source of food and of financial and social security. In such societies, cattle and buffalo and to a lesser extent, sheep and goats — described as the poor man's cow — become what may be described as a "walking bank balance" which also bears interest when the animals produces calves, lambs and kids.

Thus, where there is secure settlement, with large areas of adjacent grassland as yet unsuitable for crop agriculture, livestock rearing becomes an important dimension of livelihood. This is typical of Urir Char and parts of Char Nangulia in the unprotected areas. Also for families living within the embankments where there are adjacent lands outside the dyke livestock is important. This situation is typical of parts of Char Clerk and Char Torab Ali in the west of Subornachar, parts of Char Majid and Char Mohiuddin, parts of Char Elahi in Companiganj, parts of Char Chandia, Char Darbesh and Sonagazi Unions in Sonagazi Upazila, the area outside the dyke along the South Hatiya polder, as well as Manpura island.

6.2 REARING SYSTEMS IN THE UNPROTECTED AREAS

On the island of Urir Char almost all families rear cattle, with a typical holding of 4-6 head. Among the 4-6 head of cattle, at least one head is a milk cow. Perhaps 90% of households rear Black Bengal goat, with a holding of 2-3 animals. Almost all households have poultry with typical flocks of 12-15 chickens and 5-8 ducks. A few households (4%) rear sheep, with the flock size ranging from 10 to 40.

6.2.1 *Bathan* Operation

Some cattle, buffalo and sheep are reared in "*bathan*" systems, in large herds in open grazing land. Most *bathan* owners have their own *killa*, a large raised mound of compacted earth where animals cab be protected from tidal surges and stay at night time. The *killa* normally has a fenced space for this purpose. The person who takes care of the herd is called a "*batainna*". He normally earns Tk 2,500-3,000 per month including food or Tk 3,500-4,000, excluding food. In Urir Char there are 55-60 buffalo *bathan*s, 50-55 cattle *bathan*s and 18-20 sheep *bathan*s. A *bathan* typically ranges from 30-300 head of cattle, 50-200 buffalo and 100-200 sheep. About 75 individuals own these *bathan*s. Half of the owners are from elite households in Sandwip and Companigonj Upazilas. There are a few smaller *bathan*s, which have evolved and are managed by several families in partnership.

6.2.2 *Borga* System of Share Rearing for Ruminants

The wider distribution of livestock holdings in unprotected chars like Urir Char and Char Nangulia may be partly explained by the "*borga*" rearing system. Most sheep rearing households, an estimated 60% of cattle rearing households and 30% of goat rearing households rear the animals according to the *borga* system, the equivalent of a share cropping system in crop cultivation. Under this 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 that is in charge of rearing. In case of cattle, for example, if a bull calf is bought for Tk 5,000 and is sold for Tk 15,000 after rearing 1-2 years, the owner gets Tk 10,000, while the rearer retains Tk 5,000, although the price has risen considerably since. In the case of milch cows, the milk and the first calf is retained by the *borga* cropper. (S)he — and often it is a lady — receives a 50% share of the next calves. The cow then remains with the investor and when sold, he receives the profit. This is a highly effective system that includes a strong social custom in this particular community.

Under this system, cattle and sheep are taken in the morning by the *borga* croppers to the grazing land near the river bank and are brought home at dusk. This is done by their family labor. It sometimes happens that the male member leaves the cattle and sheep at the grazing area while on his way to other work (day labor, agricultural activities, fishing etc.). He then takes them home when he returns. Cattle are kept near the dwelling house in a corral. Here they are provided with water, grass, straw and salt. Pulse shells in the *rabi* season and rice bran in the *aman* season are added to the daily feed. Goats are mainly grazed on grasses found on the roadside, in the homestead, at the pond side, on *ails* (rice field bunds) and on fallow lands. They are not taken to the open grazing land, since they cannot retreat in the event of a high tide which floods the grazing lands on most days. By contrast, cattle, sheep and buffalo can easily walk or swim back to higher land or *killa*s.

6.2.3 Production and Sale

Milk

As noted above, each of the cattle rearing households has at least one milking cow. In the *bathan* system, an average of 40% of cattle are milch cows. Average milk production per cow is 2-2.5 liter per day and for buffalo 3-4 liter per day. Internal market consumption of milk and meat is negligible and most is therefore sold to traders who collect milk from individual households or from the *bathan*. Buffalo milk is solely used for curd preparation. Cow's milk is used for preparation of sweets, ghee production, tea making etc. Normally the price is Tk 16-20 per liter for cow's milk and 20-25 taka/liter for buffalo milk. However, if the milk is sold in advance (based on a loan), then the price falls to Tk 14-15 and Tk 18-20, respectively.

Milk produced in Urir Char is transported to Noakhali and Sandwip. On average, 800-1000 kgs Of milk is transported to the mainland daily. If the traders fail to transport the milk, they start the process of curd making at the trawler ghat in Urir Char. There are 2-3 such premises processing curd. The semi-prepared curd is then transported by the next trawler.

Cattle and Small Ruminants

People sell their bullocks or buffalo at the age of 2-3 years. Normally milking cows are sold after 4-5 parturitions. The Eid festivals are the peak time to sell bullocks and goats for meat. Durga Puja, the Hindu festival, is the favored time for sale of castrated bucks and sheep.

Income

In Urir Char, it is estimated that average household incomes from ruminant livestock range from Tk 15,000-25,000 per year. There is also some value added from cow dung, which has limited use in rice and vegetable farming, tree planting, fuel and fish culture.

Incomes would be higher were it not for widespread disease. Anthrax, foot and mouth disease (FMD), dysentery, haemorahgic septicaemia (HS), tongue infections, pneumonia etc, are common for cattle and buffalo. Goats suffer from Peste de Petits Ruminants (PPR) and, especially in the case of kids, pneumonia.

There is no formal veterinary service on these chars. Typical of the situation is Urir Char, where there are four village doctors who visit the households and *bathan*s on their own initiative and provide services for a minimum fee. Use of herbal treatments like turmeric, neem leaf, akon leaf, garlic and onion extract, mustard oil, hibiscus leaf etc. are common.

6.2.4 Poultry Rearing

Almost every household practices small-scale poultry rearing, on average 4-10 deshi (local) hens per household. These are reared on a scavenging basis in and around the household, mainly by women members of the family.

Productivity of poultry rearing is also badly affected by diseases such as ranikhet (Newcastle Disease), fowl pox, fowl cholera and duck plague, much as elsewhere in rural Bangladesh (see below). There are no vaccination services. Just as with large livestock, poultry is only treated by "quack" doctors. Sometimes balm ointment is used for poultry.

There is a particular problem in the unprotected chars, namely that in the dry season poultry and ducks face a major shortage of fresh water. Duck rearing was found mostly in the rainy season and not in the dry season due to the water crisis. In the rainy season about 50% of households can rear ducks (5-7 ducks on average) but in the dry season this percentage falls to 5-10%. Those rearing ducks in the dry season mostly live on the riverbank. Another problem of chicken and duck rearing is hunting by jackals from the scrub forest.

Poultry are mainly reared for home consumption. Surpluses are sold to traders who collect poultry and eggs from the homestead. The sales price of ducks ranges from Tk 60-100 per kg, that of chickens from Tk 80-90 per kg. Chicken eggs are sold at Tk 14-16 per *hali* (4 eggs). Duck eggs are sold at Tk 16-18 Tk per *hali*.

The above description of the livestock system in the unprotected char lands presents a system suggesting little change over time, although with reference to adaptation to the regular tidal surges which affect such areas. With reference to this description, it must be borne in mind that these char lands have not suffered an extreme climatic event in recent years, unlike the coastal areas of southwest Bangladesh through Cyclones Sidr and Aila. Nevertheless, such areas remain highly vulnerable to such events which appear to be getting more intensive as a result of climate change. Such events may decimate the livestock population, particularly poultry birds, as demonstrated by the effects of Aila on the unprotected areas of Hatiya island in 2009. Although this area was peripheral to the event, it resulted in the loss of nearly 30,000 poultry birds, over 900 goats and sheep and over 100 cattle among the RFLDC (Regional Fisheries and Livestock Development Component) project beneficiaries alone.

6.3 LIVESTOCK REARING IN THE OLDER CHARS

From the above discussion, it appears that rearing of large livestock is a more important part of livelihood in the unprotected chars than in the areas within the dykes where crop cultivation has become a more important part of the economy. Nevertheless for most of the households in the Noakhali chars, livestock rearing does play a significant role in livelihood and could play a more important role with appropriate development initiatives. There has been some attempt to intensify rearing systems in the same way as already described for fish culture, but unfortunately these have rarely been focused on the specific needs of resource poor households. On the whole, livestock systems remain extensive and low yielding.

The following tables focus on the so-called "New Chars" which were included in CDSP IV, starting from 2011. At the start of CDSP IV none of these were empoldered but differed in their date of settlement and location. Thus, Char Ziauddin lay between chars already empoldered in CDSP I and II while Char Nangulia is a large char rather inland. Char Nangulia and Noler Char were the focus of empoldering in CDSP IV. By contrast, Caring Char and as we have seen, Urir Char, remain relatively exposed. Table 6.1 offers an overview of the profile of livestock rearing in these Chars in 2012-13. It reflects the importance of milch cattle rearing (and to some extent buffalo and sheep) in Urir Char where incomes from livestock as a whole were almost 15% of total income.

Table 6.1 Profile of Livestock and Poultry Rearing in the CDSP IV Chars

Variable	Char Ziauddin	Char Nangulia	Noler Char	Caring Char	Urir Char
% HH with milk cow	33	42	45	31	67
% HH with goat	10	13	13	28	29
NGO Avg. Livestock Holdings					
Cattle and Buffalo	1.11	0.97	1.15	0.81	2.32
Goat and Sheep	0.58	0.70	0.67	1.34	1.59
Poultry	10.29	8.88	8.26	8.31	14.25
Income from livestock	879	1,993	2,213	1,439	13,531
Income from poultry	1,380	1,768	1,373	2,161	3,831
Total income	**65,743**	**69,152**	**69,281**	**71,475**	**104,400**

Source: CDSP IV (2013), Baseline Survey of Social and Livelihoods Component.

6.3.1 Large Livestock Rearing

Table 6.2 drawn from the overall CDSP IV Baseline Survey focuses more specifically on large livestock and shows that 75% of sample households are rearing ruminant livestock of one type or another (cattle, buffalo, goat and sheep), 41% of the sample households have at least one milking cow, 41% have a bull (for draught or fattening) and 17% have a goat. Only in Urir Char there is considerable number of households (12%) with buffalos, with an average number of 7 animals. The Baseline Survey of the Social and Livelihood Component conducted in 2013 offers data on average holdings of ruminant livestock. In line with the baseline (Table 6.1), average cattle and buffalo holsings is just one animal per household, except for Urir Char (2.12) and less than one head of goat and sheep except for Caring Char (1.39) and Urir Char (1.59). Perhaps 90% of households rear Black Bengal goat, with a holding of 2-3 animals. A few households (4%) rear sheep, with the flock size ranging from 10 to 40.

Table 6.2 Characteristics 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 livestock	65 (65%)	468 (78%)	222 (74%)	213 (71%)	85 (85%)	1053
HH with milking cow (%)	33	42	45	31	67	41
Average no. of cows	1	1	1	1	2	1
Avg. milk production (Lt)	99	91	118	104	203	114
Avg. milk consumption (Lt)	48	46	70	70	110	64
Avg. income from Milk (Tk)	2970	2730	2950	2600	4060	2850
HH with bull for draught and fattening (%)	28	47	39	28	67	41
Average nos. of bull	2	2	2	2	3	2
HH with goat (%)	10	13	13	28	29	17
Average nos. of goat	2	2	2	3	3	02
HH with buffalo (%)	1	0	1	0	12	1
Average nos. of buffalo	3	1	7	0	7	6
HH with sheep (%)	0	0	0	0	3	0.2
Average nos. of sheep	0	0	0	0	4	4

Source: CDSP IV, Draft Baseline Survey Report, February 2012.

Animal Breeds

Almost all the ruminants reared in the Noakhali char lands are local breeds. A baseline survey done by RFLDC in 2007 for the whole region of Greater Noakhali (the Districts of Lakshmipur, Noakhali and Feni) offers more detail on the technical aspects of the system, and indicates that less than 2% of sample households have cross-bred cattle and only 0.9% of the households have "only cross bred" animals. Moreover, there was not a single cross-bred sheep, goat, buck or buffalo in the entire sample.

There has also been very little attempt to upgrade the stock of animals. In Bangladesh, the Department of Livestock Services largely promotes breed improvement through the use of Artificial Insemination using chiefly semen of Holstein-Friesian-Sindhi or Sahiwal cross-bred cattle. However, of 223 eligible cattle which were used for breeding in the year prior to the baseline survey, only 18.4% were taken for artificial insemination and 65% were serviced through natural means. The remaining 16.6% were not taken to service at all. Among the naturally bred animals, 80 % of the households used stud animals from within the village. Others either used sources from outside the village (13%) or from in-house (6%). The artificial insemination was done for cows only. The sources were mostly the Department of Livestock Services (74%) followed by NGOs, for instance BRAC (16%) and others (10%). For this activity the households had to travel an average distance of 1.9 km. No goats were serviced through artificial insemination; 78% of the eligible animals obtained service by natural breeding, the remainder not at all.

Fodder and Feeding

The majority of ruminant livestock in the char lands are fed through open grazing methods. In the RFLDC Baseline Survey as a whole, almost two-thirds of local cattle were fed in this way, while a further 11.6% were partly fed through open grazing and were partly stall-fed. In AEZ 18 (Table 6.3), which includes the char land of Noakhali District, 72.4% were fed through open grazing alone and another 17% by a combination of grazing and stall feeding. In the case of local goats (including sheep), 68% of animals were fed in a rough grazing system and another 18% by a combination. These numbers increased to 76% and 22% respectively in the char area.

Among cross-bred animals, many of which were probably milk cows, the picture is a little better. In the Noakhali chars, 35.3% of the cattle were raised in a stall-based system, with another 6% using both methods.

Table 6.3 Nature of Rearing by Type and Breed Cattle and Goat (% of Households by System)

System	Noakhali				
	AEZ17	AEZ18	AEZ19	AEZ23	All
A1. Local Cattle					
Scavenging only	51.0	72.4	57.6	63.3	64.7
Closed/In-house	43.0	10.7	40.4	23.3	23.8
Both	6.0	16.9	2.0	13.3	11.6
A.2 Crossbred Cattle					
N	100	272	99	30	501

Continued

Table 6.3 Continued

System	Noakhali				
	AEZ17	AEZ18	AEZ19	AEZ23	All
Scavenging only	100.0	58.8	83.3	50.0	75.0
Closed/In-house	-	35.3	16.7	50.0	22.7
Both	-	5.9	-	-	2.3
N	11	17	12	4	44
B-1 Local Goat					
Scavenging only	57.1	75.7	25.0	66.7	67.9
Closed/In-house	32.1	2.8	58.3	33.3	14.1
Both	10.7	21.5	16.7	-	17.9
N	28	107	12	9	156

Source: Pathways (2007).
Notes: Cattle includes buffalo and goat includes sheep; Agro-ecological Zone 17 coincides with the riverine chars of Lakshmipur, AEZ 18 with the main area of char lands in Noakhali, AEZ 19 corresponds with the fertile plain lands of Feni and AEZ 23 with the foothills on the Indian border in Feni and adjacent parts of Mirsarai Upazila in Chittagong District.

Where animals are stall-fed, for local animals the fodder provided predominantly consists of green grasses and straw from the fields, while cross-bred cattle are given some supplements such as rice bran, rice gruel and oil cake. A few cross-bred cattle are also fed with straw fortified with urea and molasses.

Animal Health Care

The productivity of large livestock in the char lands continues to be constrained by the incidence of disease. In the RFLDC Baseline Survey, 51% of households reported that one or more of their cattle had suffered disease in the previous year; 31% of households reported disease in their goats. The most frequent problems were Foot and Mouth Disease (31%) of cases of cattle, Bloat (15%), ephemeral fever (10%) and Haemorraghic Septicaemia (9%). In the case of goats the problems were Bloat (24%) and Peste de Petits Ruminants (PPR) (20%). In 90% of cases, the survey respondents regarded the disease outbreaks as severe or moderately severe.

In 92% of cases of disease in cattle and 82% of cases in goats, respondents treated their animals. However, most turned to village livestock workers (43% and 46% for cattle and goats, respectively) or attempted to treat the disease themselves (17% and 26%). Relatively few turned to the Department of Livestock Services. Despite treatment, in 12% of cases of cattle disease and 23% of cases of goat disease, the animals died.

Despite the incidence of disease and although most farm households do attempt to treat sick animals, they appear reluctant to take preventative measures. Over half of households claimed no interest or the lack of need for vaccination, an indication that most had not suffered a serious disease problem during the year. In fact, only 19% of households in the baseline survey said they had vaccinated their animals in the previous year overall and only 24% of the households owning cattle. Amongst the poorest households in the study, the rate fell to only 15%. The figures for the char areas were slightly better, maybe reflecting their importance in the livelihood system; here 30.6% of households vaccinated their cattle and 12.5% their goats, much the highest figure amongst the different agro-ecological zones.

In the case of cattle, 53% of farmers actually protected their animals by vaccination against Foot and Mouth Disease, compared to 16% against Haemorraghic Septicaemia, 15% against Anthrax and 12% against Black Quarter. In the case of goats, 20% of households vaccinated against all possible diseases. For cattle vaccination, veterinary officers of the Department of Livestock Services were the main source of vaccine (47% of households), with community livestock workers/"paravets" mostly trained by NGOs or projects — see below) as the other major source. In the case of goats, the "paravets" play a greater role. Amongst those vaccinating, vaccine was said to be generally available, but of those not vaccinating, lack of vaccine and the non-availability of vaccinators was cited by 12% and 25% of respondents as the reason for their decision not to protect their animals.

Income from Large Livestock

Livestock are typically seen as "a walking bank balance". Nearly a quarter of households in the Noakhali region sold animals, almost 80% of them cattle. For these households, the cattle constitute a significant source of income. Those selling on average disposed of 2.5 head of cattle with an average price of around Tk 11,000 per head. Most sales took place at the local livestock market (*Gorur Hat*). Many sales take place at the time of the Muslim festival of Eid-al-Asha. Farmers often buy cattle several months in advance to fatten them up for sale at a profit.

Sales of livestock products are dominated by milk; 30% of households recorded as rearing ruminants in Noakhali during the baseline survey sold milk. The average income from milk sales was just Tk 4,970 per household. This reflects the fact that most households only have one or two milking cows, only one of which may be lactating for part of the year. It also indicates that the cows are low-yielding local animals, with a typical yield of only one liter per day, and that the price of milk in isolated parts of the chars is very low because high transportation costs hindered export to the mainland. In 2007, the milk price was typically only Tk15-20 per liter, although there has been some increase since then. Over 45% of respondents in Noakhali complained of marketing problems, especially low price, poor communication and large distance from market.

6.3.2 Poultry Rearing in the New Chars

Table 6.4 shows that 89% of all households in the new chars in 2012-13 reared poultry, almost entirely (99%) through a semi-scavenging system (scavenging plus use of a small amount of supplementary feed). The average number of birds for each household is six chicken and seven ducks. Flocks in Urir Char are slightly higher than the average, in line with the rather larger resource base per household, but unlike the ruminant sector, there is no major difference from the other chars in the rearing system. This general pattern is confirmed by the Baseline Survey of the Social and Livelihood Component conducted in early 2013, although the average holdings recorded tend to be lower at nine birds (chickens and ducks) overall and 14 birds in Urir Char.

Average egg production per year is 156 from both duck and chicken and total meat production is 36 kg per year. Consumption of eggs (30% of households) is more than the consumption of meat (17%). Average yearly per household income from eggs is estimated to be Tk 817 and from meat Tk 4,949. The female members of the households reportedly carry out the rearing of poultry birds. In a few cases the male members do the task and the women assist.

Table 6.4 Characteristics of Poultry Rearing Systems

Rearing status	Char Ziauddin (N=100)	Char Nangulia (N=600)	Noler Char (N=300)	Caring Char (N=300)	Urir Char (N=100)	All (N= 1400)
HH rear 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
Fully supplementary feed (%)	0	0	0	0	0	0
Average Nos. of Chicken	4	6	5	6	9	6
Average Nos. of Duck	7	7	6	6	9	7
Annual production of eggs	275	139	127	208	209	156
HH consumption of eggs	84	39	43	56	64	47
Income from eggs	1210	660	760	1108	1372	817
Annual production of meat (Kg)	47	32	26	42	75	36
HH consumption of meat (Kg)	7	5	3	7	10	6
Income from meat (Tk)	9009	4307	4961	5010	7881	4949

Source: CSDP IV, Draft Baseline Survey Report, February 2012.

It was demonstrated above that the vast majority of households in rural Noakhali rear poultry, over 80% of them rearing chickens and almost two-thirds of them rearing ducks. The CDSP IV surveys do not offer a breakdown, but the RFLDC Baseline Survey again offers more detail on the rearing system. In 2007, the vast majority of households reared local (deshi) chicken. Remarkably few households reared the semi-improved Sonali and Fayoumi chickens, despite the promotion of the former under the Smallholder Livestock Development Project (see section 6.4.2) in the region since 2002. Only a slightly larger number rear improved breeds of duck, despite the presence of a Government of Bangladesh duck breeding farm at Sonagazi in the eastern part of the Greater Noakhali region. An equally small number of households (0.5%) operate commercial layer and commercial broiler farms. It should be noted at the outset that poultry rearing is almost exclusively carried out by the women in the household.

Breeds and Rearing Methods

Local birds are typically (89% of rearing households) reared on a scavenging basis, although it is interesting to note that in the Noakhali chars (AEZ 18) this figure falls to 78%. As many as 21% of households in the chars rear through both scavenging and on a confined basis. This may reflect the promotion of the semi-scavenging technique under the Smallholder Livestock Development Project including the work of NGOs. However, confinement of the birds does not necessarily mean an improved diet, since the feeds offered were mainly poor in nutrients. The only significant feeds given to poultry birds are rice, rice bran, paddy and a mix of some broken wheat, maize and rice. The feeds are pretty much the same for chickens and ducks (Table 6.5).

Table 6.5 Type of Food Given to Poultry (% of Households Rearing)

Name of Food	Local Chicken	Farm Chicken	Duck/Goose	Other	All
Water	45.2	100.0	55.7	100.0	51.9
Rice bran	77.4	14.3	85.2	12.5	78.2
Wheat Bran	11.4	12.9	-	11.6	-
Broken Wheat/Maize/Rice	45.2	14.3	24.5	79.2	-
Crushed oyster shell	0.5	14.3	12.8	2.1	5.9
Feed additives	0.3	-	0.2	-	0.2
Formulated Branded Feed	-	85.7	-	0.4	-
Rice	92.5	-	86.2	33.3	87.3
Paddy	32.8	-	37.6	66.7	35.9
No Households Rearing	743	7	596	48	1394

Animal Health Care

Productivity of poultry is affected by disease, even more than is the case with large livestock. Overall, 65% of households rearing birds in the RFLDC Baseline Survey reported disease amongst poultry in the year prior to the survey. Incidence of disease was 85% for local chicken and 50% for ducks and geese. The biggest problem in the case of local chicken was Ranikhet (78% of all cases), followed by fowl pox (31%) and fowl cholera (24%). The most widespread problem among ducks was duck plague (38%) and duck cholera (33%). In most cases (73%), the outbreak was described as severe.

Amongst households reporting disease, 69% among chicken rearers and 61% among duck rearers said they had treated the disease. In the majority of cases (46% and 50%) they had given treatment themselves. Others had recourse to input sellers (16% and 13%) or received services from local poultry workers (14% and 11%). Notably almost none had received services from the Department of Livestock Services or directly from NGOs. Perhaps not surprisingly, in the majority of cases (62% for chickens and 58% for ducks) the treatment did not work in the sense that the birds died anyway.

Despite this experience, only 23% of households rearing local chicken and 10% rearing ducks and geese had vaccinated their birds within the previous year. These figures for the whole of Noakhali are higher than for the char land region where only 16% of households rearing chicken and 9% of those rearing ducks vaccinated their birds. As far as vaccination took place, it was mainly against Ranikhet (80% of all households) vaccinating with much lower percentages for fowl pox (28%) and fowl cholera (17%).

The main source of vaccination services in the Noakhali region was from village poultry workers (just over 50%), followed by NGO workers (18%); 14% of households treated the birds themselves. This is significantly different from the situation in Barisal where self-treatment dominated. This demonstrates probably the positive impact of development efforts by the Smallholder Livestock Development Project and by NGOs in Noakhali.

Among the majority of households who had not vaccinated their animals, about one-third said they were not interested or felt that it was unnecessary, while others cited the non-availability of vaccinators. This suggests there is a considerable potential for expansion of vaccination services in Noakhali.

Income from Poultry

Some 27% of respondent households in the baseline survey sold poultry birds in the year prior to the survey in 2007, mostly (72%) in the local market. The average number of birds sold per household was 10 chickens and 10 ducks. Given an average price of Tk 105 for chickens and Tk 103 for ducks, this gives an average return of some Tk 2,080 from poultry sales per year. Some 23% of households rearing poultry birds in Noakhali also sell eggs. Average income from egg sale in the year prior to the baseline survey averaged Tk 635 per household.

6.4 DEVELOPMENT OF ANIMAL HUSBANDRY IN THE CHARS

The descriptions of the livestock rearing systems in the Noakhali chars contained in Section 6.2 shows that animal husbandry is a very important element in household livelihood in the unprotected chars. This is based upon the access to rough grazing areas still affected by tidal surges. Farmers, some of them well-off families from outside the chars, rear large herds of cattle, buffalo and sheep in these areas, as well as rearing poultry and goats in the homestead. They do this largely in the absence of support services from the government. When the chars are empoldered or even become more consolidated, improved water control offers the opportunity of conversion of these grazing lands to crop agriculture and the scope for extensive grazing systems declines. In the protected chars, fewer households rear large and small ruminants. For animal husbandry to continue to make a real contribution to the livelihood system, a degree of intensification is required. The parallel with the shift from capture fisheries to aquaculture will be apparent.

Unfortunately, as the description in Section 6.3 demonstrates, the livestock rearing systems of the Noakhali char lands in 2012-13 remained underdeveloped. Most households continued to rear native breeds of ruminants and poultry, mainly under extensive grazing or backyard scavenging systems, with limited supplementary feeding. Faced with widespread problems of animal health, most farmers followed a curative strategy, seeking to treat their animals when they fell ill, rather than a preventative strategy, through improved husbandry and regular vaccination of stock. Particularly in the more isolated areas, access to veterinarian service remained extremely restricted and farmers often treated their animals themselves or turned to unqualified traditional "*dakter*" in the village. Hence productivity remained low. Beef cattle grew slowly and milk yields were low. Mortality amongst poultry makes what should be a low-cost, key element in household nutrition, actually a risk for the rural poor.

6.4.1 Department of Livestock Services

Development of the livestock sector in Bangladesh is in the hands of the Department of Livestock Services. The Department published its National Livestock Development Policy in 2007. This notes the importance of the livestock sector nationally, with a contribution of around 3% of GDP. It claims 75% of the population rely on livestock to some extent for their livelihood and notes that livestock has been the fastest growing sub-sector in agriculture in recent years. However, it notes also that productivity is extremely low and livestock products (milk, meat and eggs) provides no more than 20-30% of the current latent demand in the country. Shortages of quality inputs, inadequate services and physical infrastructure, institutional weaknesses, limited skilled manpower, and inadequate research and technology development are identified as constraints to livestock development.

These constraints, which are mainly institutional rather than technical, are reflected in the situation in the Noakhali chars. Like the Department of Fisheries (Chapter 5), the Department of Livestock Services locally has severe limitations in extending services in the rural areas, especially when they are isolated. The Department of Livestock Services has a larger staff at Upazila level than the Department of Fisheries, since it has two functions, veterinary care and extension. Thus, in a typical Upazila Office there is an Upazila Livestock Officer and his deputy, with perhaps one Field Assistant, and a Veterinary Surgeon, supported by one or more Veterinary Field Assistants and a Compounder (for mixing medicines). However, just as with the Department of Fisheries, at any one time some of these positions will not be filled. It is a feature of the situation in Noakhali that often the Veterinary Surgeons are Upazila Livestock Officers in charge. A particular problem now facing the Department is that most Veterinary Field Assistants were trained under a specific project over two decades ago and most are nearing retirement. There is no ongoing mechanism for training a new cadre. The same is true of the cadre of Artificial Insemination Volunteers, who are stationed at small units at Union level, sometimes even in the Union Parishad complex. Most are close to retirement and it is not obvious that they can be replaced.

The Upazila Livestock Offices are usually situated in what are termed Upazila Livestock Development Centers (ULDC), which apart from the Upazila Livestock Office itself may contain an artificial insemination center and a service for treatment of large animals. These Centers are backstopped by District Veterinary Hospitals, to which problems may be referred and to which requests for diagnostic tests can be directed (for example, preliminary diagnosis for Avian Influenza). The ULDC should be equipped with a refrigerator for storage of vaccine. This is in many ways theory; in practice many of these facilities lack maintenance and have fallen into disrepair. Thus, for example, refrigerators have broken down, making it impossible to maintain the cold chain. The chain is usually already compromised by the unavailability of chiller vans to transport the vaccine from the central production facilities in Dhaka and Comilla and by the erratic supply of vaccines in general.

Moreover, in the absence of donor-supported projects, the Upazila Livestock Officers and particularly the Veterinary Surgeons lack transport facilities which would enable them to extend their services to the vast majority of poor clients in isolated areas like the chars. Several extension projects have supplied motorcycles to Upazila Offices, but rarely is a separate motorcycle provided to the Veterinary Surgeon. This means that veterinary services are seldom available more than a few kilometers from the Upazila headquarters. This situation reinforces a tendency for veterinarians in particular, to serve only the larger, more commercial peri-urban farmers (small-scale commercial dairy farmers, layer and broiler farms) who will pay extra for those services. These same farmers tend to be the focus of whatever the training events are organized by the Upazila Livestock Officer.

6.4.2 Development Projects

Thus, providing livestock extension and wider veterinary services to the mass of the resource-poor farmers in Bangladesh, as with the Department of Fisheries, has depended largely upon donor-funded projects. Since these projects have mainly emphasized the role of livestock in poverty alleviation, especially for women, their main focus has been on poultry rearing. Indeed in the poultry sector, donors, notably Danida, the Asian Development Bank and the International Fund for Agricultural Development (IFAD), have funded a series of projects variously known as the Participatory Livestock Development Project (PDLP) and the Smallholder Livestock Development Project (SLDP). These projects have promoted what has come to be known as the Bangladesh Poultry Model.

The Bangladesh Poultry Model and SLDP-2

The most recent manifestation of the Bangladesh Poultry Model was the Smallholder Livestock Development Project in the Five Southern Districts (SLDP-2), which covered the three districts of Greater Noakhali, as well as two Districts of Barisal Division. This project began in 2002, ending in 2006. It is this Danida-funded project which was the forerunner of the Regional Fisheries and Livestock Development Component, Noakhali, which operated in the Noakhali chars. The main objective of this project was income generation for famers through increased and sustained productivity of backyard or family poultry, as well as capacity building of local institutions. Like GNAEP (see Chapter 5), SLDP-2 hired local NGOs to carry out the farmer training under the project and to provide credit to facilitate the beneficiaries in technology adoption.

SLDP-2 in its original design followed the Bangladesh Poultry Model, merely extending a model tried elsewhere to the five southern districts. The model involves the development of six different enterprises in the promotion of backyard poultry farming, three production enterprises (Key Rearers, Day-old Chick Rearers, Mini Model Breeders) and three support enterprises (Poultry Worker, Feed Seller, Egg Collector).

Under this model, the Key Rearers are the main beneficiary farmers (95% of all beneficiaries). Their enterprise has two different segments: (a) the layer hen part for the production of eggs; and (b) the local (deshi) hen part for hatching and rearing of chicks. Under (a), the Key Rearers are provided with 5-6 pullets of the semi-improved Sonali breed from the Day-old Chick Rearer. Under (b), the beneficiary is also provided with 3-4 deshi hens to act as broody hens for hatching of the eggs produced by the deshi hens themselves as well as by the Sonali birds. Chicks hatched are kept confined in a basket and offered balanced feed. The broody mother is separated from the chicks after a short period and fed a balanced diet to induce her to quickly lay the next clutch of eggs (also known as "creep feeding").

The Day-Old Chicks of the Sonali breed are raised to pullets (eight weeks) by the Day-old Chick Rearer. These chicks are produced by Government hatcheries and are vaccinated before delivery. After segregation at five weeks, the male birds are sold to the local market. The female birds are then distributed to the Key Rearers.

The Mini Model Breeder is responsible for the production of hatching eggs of improved breeds for the Key Rearers. The Mini Model Breeder is supplied semi-improved animals at the ratio of 1 Male to 10 Females for breeding. The eggs produced are then used for hatching by the Mini Model Breeder herself or distributed to other members of the village group (Key Rearers). This enterprise gives the Key Rearer the opportunity to obtain eggs for hatching before the Sonali birds from the Day-old Chicken Rearer are ready for laying.

The support service enterprises are largely self-explanatory. The Feed Seller is meant to ensure a supply of improved feed to the Key Rearers and the Egg Seller is meant to collect the eggs for market. The Poultry Workers are basically the vaccinators for the poultry, although they also provide other treatments against parasites. These people are provided with a kit box with all necessary equipment.

Problems and Modifications of the Bangladesh Poultry Model

There is a considerable body of literature reviewing the achievements and problems of the Bangladesh Poultry Model especially in terms of its impact on livelihood of the rural poor. There seems to be no doubt that the basic assumption that improvement of poultry rearing on a semi-scavenging basis can indeed have a useful effect upon livelihood. The main questions in relation to the poultry model appear rather to be whether the model with its dependence on the supply of external inputs, centered on the provision of Day-old Chicks of semi-improved breeds, is a sustainable one.

The evidence of SLDP-2 at the end of the project in 2006 seems to suggest that the model is too dependent on the supply of these external inputs through the NGOs. The withdrawal of the NGOs at the end of the project led to the removal of the supply chains on which it depended. Even during the project period, the NGOs themselves were constrained in ensuring the regular supply of breeding animals for the Mini Model Breeders and of Day-old chickens for the Chick Rearers by limitations of the Government of Bangladesh system. The same thing can be said of supply of vaccine for the Poultry Workers. Thus, there were constraints both in terms of quantity of supply (not enough birds) and quality (high mortality during delivery and doubtful effectiveness of the vaccine because of the failure to maintain adequate supplies and because of the inadequate cold chain). In the latter context, the regular supply of vaccine to the Poultry Workers immediately broke down at the end of the project. While some more enterprising women sought out their own supplies from the Upazila Livestock Office and private sector suppliers, many women living in more isolated contexts and less mobile, just gave up the activity.

Analysis of the system made it clear that the critical interventions in the whole model were (a) removing the chicks from the broody hen at an early stage; (b) improving the nutritional status of the broody hen through supplementary feeding on the nest, both to increase the number of clutches to be reared in a year; (c) so-called "creep feeding" of chicks in a protected run; and (d) ensuring a regular supply of reliable vaccine. These four interventions would bring about a major increase in productivity from local hens, rearing of which would also reduce rearing costs because of their lesser dependence on improved feeds. This has been termed the "Simplified Poultry Model".

Regional Fisheries and Livestock Development Component (RFLDC)

As the successor project of SLDP-2, the Regional Fisheries and Livestock Development Component, Noakhali, tried to build on its experience. RFLDC incorporated poultry rearing in its Farmer Field Schools (see Chapter 5 for detailed description) where a key learning module was how to improve the rearing of deshi chickens. In successive learning sessions, farmers experimented with testing out improved brooding technology, removal of the broody hen from the chicks at different dates and supplementary feeding. For the feeding they learned also to use as much as possible ingredients available on-farm. Farmers also became familiar with the different diseases of poultry and the schedule for vaccination. The Farmer Field Schools provided the technology dimension; the community-based organizations (again already discussed in Chapter 5) provided an institutional home for the Poultry Workers and thus help them to obtain regular supplies of vaccine.

Rebuilding the vaccine supply chain under RFLDC, Noakhali, was not easy. It was quickly recognized that, in the absence of the NGOs, the CBOs would have to play the role to ensure the supply down to the grass roots level. However, maintaining the cold chain to this level required that CBOs and District level CBO Associations formed from groups of CBOs to invest in their own refrigeration facilities. RFLDC supported this through a block grant facility it provided to the Union Parishad, for which the CBOs could apply to obtain an investment grant. Even so, there are basic supply constraints in the Government of Bangladesh supply chain down to the Upazila level. Often, as we have seen, not enough supplies of vaccine are available and questions were being asked about quality since the vaccine was sent down to Noakhali in cool boxes on normal service buses. This problem was most extreme in the isolated chars, where also the electricity supply was either erratic or non-existent. To ensure regularity and quality of supplies, RFLDC encouraged the CBO Associations to make their own arrangements to collect vaccine from the Department of Livestock Services production facility in Dhaka and eventually and more sustainably to seek alternatives from the private sector where possible.

SLDP-2 was largely focused on chickens. It did contain the possibility of project farmers diversifying into ducks and small ruminants with a further loan, but the sophistication of the Poultry Model was absent in these cases. Under RFLDC, the scope of activities in the livestock sector widened to include ducks, small ruminants, both goats and sheep, cattle fattening and, in a few cases, dairy farming. Where their inclusion was requested by farmers, all of these types of livestock were included in the Farmer Field School, with the emphasis on farmer discovery of what might be the appropriate rearing methods. Thus, for example, in the case of ruminants, a key issue emerging was feed management. The animals had to be provided with adequate feed at all times of the year to ensure good nutritional status. This would ensure, for example, the fecundity of the Black Bengal Goat and reduce mortality amongst goat kids, as well as maximize the returns from the highly profitable cattle fattening operation. To this end, farmers were expected to review their resources and to compare the feasibility of different strategies such as cut and carry of wild grasses, cultivating improved green grasses on their available land and use of urea-molasses straw as a supplement.

However, in the same way as with poultry rearing, the FFS learning sessions needed to be complemented through ensuring the input supply system. Here RFLDC experimented with ways to break the existing constraints to further development of all of these enterprises which had considerable potentials in the Noakhali chars. Apart from the feed issue discussed above, these constraints were very similar to those faced in poultry (chicken) rearing: regular supply of young animals at reasonable price, supply of improved feed, veterinary care and marketing. A number of key questions were:

Breeds: How to ensure a reliable supply of improved breeds of Day-old Ducklings when the Government farms, which were the main suppliers, could not offer sufficient supplies and often channeled their available supplies through agents? How to ensure a supply of good quality Black Bengal Goats in the context of deterioration of stock quality? How to offer opportunity for improving cattle stock for resource poor farmers from local improved breeds, such as Red Chittagong, as an alternative to upgrading through Artificial Insemination of Crossbred stock, which require feed and husbandry beyond the scope of the poorer farmers?

Feeds: How to identify appropriate feeds and fodders which fitted into the existing farm system, which could easily be grown in the various soil conditions of the coastal region and which together could offer a year-round supply of nutritious feed? How to supply planting materials for fodder crops on a regular basis?

Veterinary care: How to encourage farmers to move towards a preventative attitude to animal health as opposed to response only when their stock required treatment? How to ensure a regular supply of veterinary medicines, including vaccines, to the most isolated areas in a sustainable way?

Marketing: How to improve the returns from and therefore encourage more investment in perishable products like milk in the face of high transportation costs and difficulties of quality control amongst small-scale farmers?

To address these problems, RFLDC, Noakhali adopted three main strategies to support its development efforts: a. promotion of adaptive research; b. encouraging investment by the private sector; and c. developing the business capacity of community-based organizations.

Adaptive Research: RFLDC benefitted from special funds available for adaptive research under Danida's Agricultural Sector Program Support. With these funds RFLDC enlisted researchers to carry out adaptive research, especially into the development of feed sources for cattle, goats and indigenous poultry/ducks, with special reference to the chars. As adaptive research, these studies focused on what could be done with the existing resource base of the farmers. Thus, the study of cattle fodder focused on fodders which were tolerant to the partly saline conditions of the chars, while the study on duck feed concentrated on indigenous duck species and the feeds available within the wider farming system.

Another thrust of research was on system development, particularly in relation to improving the rapid identification of disease outbreaks and development of a community-based system of animal health care to bring veterinary services down to the grass roots. Both of these studies were carried out by the Chittagong Veterinary and Animal Sciences University (CVASU), which became a close partner, when, in 2009. responsibility for the ASPS-II supported project in the Poultry Research and Training Centre (PRTC) in CVASU was transferred to RFLDC, Noakhali, in order to improve its management, linkages with the wider program and sustainability. The first study sought to establish a system whereby disease outbreaks could be more rapidly identified in the community and their spread tracked quickly in order to more rapidly contain the problem.

The second project, which began in 2009, explored how far it was possible for a young veterinarian to make his living in a rural area through private practice, while offering services to the resource-poor farmers. This project confronted the issue of encouraging farmers to be more proactive in animal health care and had some success in promoting regular de-worming of cattle. The project worked through RFLDC's network of community-based organizations which were responsible through Community Livestock Workers trained by RFLDC in parallel to Poultry Workers (many through PRTC/CVASU) for organizing the de-worming and other campaigns; as an example, vaccination cards were provided.(see Table 5.6 in Chapter 5). Under this project, better-off farmers were expected to pay modest fees for the services provided by the private veterinarian. The young veterinarian in Subornachar continued to work closely with the NGO, Sagorika SUS, until recently.

RFLDC hoped that the results of these adaptive research projects would feed over time into the Farmer Field School learning sessions, the ultimate objective of which was to better equip local farmers with the knowledge and decision-making skills to adapt to changing environments including changes brought about by climate change.

Co-operation with Private Agribusiness: At the end of the RFLDC Project in 2013, some of the adaptive research was still to bear fruit, but co-operation with private agribusiness had already had an impact. Based upon the successful collaboration in prawn aquaculture (see Chapter 5), RFLDC sought to encourage private sector investment in livestock, particularly in the production of improved stock of animals. One investor, for example, established a farm for the production of kids of Black Bengal goats and local sheep, which he distributed to poor farmers through the community-based organizations. The CBOs paid the market price for their kids, and offered these on the basis of credit-in-kind to the farmers, the recipients repaying a female kid to the CBO when their initial animals gave birth. Like the work with the prawn hatchery, the private entrepreneur also offered scope for the project to carry out adaptive research into improved feeding strategies. Thus, it was shown that for part of the year the goats would take a partial diet of urea and molasses treated straw. The adaptive research on goat feeding technology conducted by the Bangladesh Livestock Research Institute built upon this initiative and was also used private farms for trials of different fodders.

From the experience with the goat and sheep production unit, which is part of a larger integrated private sector farm, RFLDC began to seek partnership with other similar integrated farming enterprises in Noakhali. Some of these were importing their own input supplies, such as molasses, from other parts of Bangladesh, which would otherwise not be easily available in Noakhali. They expressed willingness to act also as wholesalers to supply the CBOs. Others agreed to provide fodder cuttings for local farmers, again to be distributed through the CBOs.

RFLDC also turned to the private sector for ensuring a regular supply of quality vaccine and other veterinary medicines. The advantage of the private sector supply was that the cold chain is maintained down to the provincial level and maybe below. RFLDC opened negotiations with a number of private sector companies for a regular monthly/quarterly delivery on the basis of identified demand. It was RFLDC's intention that the CBO Associations make their own contracts with the private sector supplier. This system was initiated in mid-2010.

Co-operation with private agribusiness was not necessarily the best strategy for ensuring input supplies to the farmers. 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, despite an initial feasibility study, it proved difficult to draw private investment into the production of day-old ducklings. A government farm in the nearby Upazila of Sonagazi sold ducklings at a substantially subsidized price (Tk 12 per bird when the real production cost was Tk 20-22 per bird), a practice which obviously discouraged the private sector. However, the subsidized prices did not benefit the duck rearers because of (a) irregular supply and (b) substantial mark-up in the informal supply chain.

Development of Agribusiness (Input Supply and Marketing) through Community-based Organizations:

i. **Input Supplies: Rice husk hatcheries for Day-old Ducklings**: The problem of Day-Old Ducking (DOD) supplies mentioned above was thus investigated through more localized production systems operated by the CBOs. An initial attempt to introduce small incubator systems proved uneconomic because of the need to establish a back-up generator in the face of uncertain mains electricity supplies. However, the so-called "Rice Husk Hatchery" system proved a more promising option. An experienced farmer consultant was hired from another district and CBO members were trained. The initial experiment was with the East Bircoat Mowhla CBO, in the waterlogged paddy zone of Senbagh Upazila, run entirely by young women; they established their own network of duck egg sellers and sold the DOD on to another nearby CBO for nursing to 35 days. Soon the technology spread to other CBOs in the chars of Companiganj, Subornachar and Lakshmipur/Raipur including Water Management Groups set up by CDSP. By 2013, some 15 such enterprises had been established, selling on to duck rearers, often organized in Producer and Marketing Groups (PMG) supported by the former FFS Local Facilitator.

ii. **Deepening Market Access**: In the last two to three years of the RFLDC, management perceived that increased production through the successful Farmer Field Schools was providing a marketable surplus, offering its members scope to improve their livelihood through higher returns. RFLDC thus encouraged the formation of Producer and Marketing Groups from the FFS to market products through the CBOs. Latterly, RFLDC contracted the international NGO, International Development Enterprises (IDE) to support this effort in a project termed "CBO Strengthening through Deeper Market Integration". This Project identified likely produce which could be sold to high level markets, promoted a dialogue with market actors and improved the capacity of the CBOs in business planning and development. Several "quick win" enterprises were identified and linkages with markets forged, mainly in the crops sector (coconuts, soya bean, country bean, okra) and handicrafts like net making.

Specific to the livestock sector, the most successful thrust was the marketing of eggs, linking producer groups mainly in Subornachar with District level buyers and it is probably the one with greatest potential for the CDSP IV area if the problem of poultry mortality can be addressed. In 2011-12, many of the CBOs in Subornachar developed Producer and Marketing Groups for both chicken and duck egg production which were producing a surplus over household needs. In February 2013, through the South Noakhali CBO Association, the CBOs sat down with a dealer based in Aktopalia Bazar to seek an agreement for bulk marketing. This dealer collected eggs from a wide area of Subornachar, including Horni and Chanandi Unions of Hatiya, and sold them in Sonapur, Maijdee and Chaumohani. It was estimated that the daily demand in these markets was 15,000 eggs. In the discussion, the dealer agreed to collect eggs on certain days from the South Noakhali CBO Association with his own transport and also from individual CBOs if they accumulated more than 2,000 eggs in any one day. He undertook to pay cash at a price higher than that offered by the local traders, although lower than the price in Maijdee market (Tk 905 per 100 eggs). Seven CBOs were involved in the arrangement, each of them offering funds to their market agents, the former Local Facilitators of RFLDC, for purchase from the farmers, These CBOs included, of relevance to CDSP, Banglabazar UBUS (Char Clerk), Saikat BUS (East Char Bata), Tankhir *Khal*-2 Water Management Group (Boyer Char), and Char Torab Ali Mokus (Gangchil). At the initial stage, the CBOs targeted collection of 3,700 eggs daily, but it with a target to increase to 5,000 eggs.

6.5 CONCLUSIONS

The Noakhali chars hold tremendous potential for livestock development not least for the most isolated areas beyond the polders, where almost certainly livestock provides the most important source of livelihood and offers an important buffer against natural hazard.

However, these potentials are constrained by isolation which denies farmers access to the appropriate information to improve their system and also to the key services such as animal health care which are crucial to development of the system. In general, the livestock rearing system in the Noakhali chars in 2011-2012 remained underdeveloped and the services provided by government just did not reach down to such isolated areas.

RFLDC attempted to address some of the key problems through simple technical improvements in the Simplified Poultry Model rearing systems under the Farmer Field School, supported by adaptive research, as well as provision of services through community-based organizations, with strong links to the private sector. It was the hope that this system would help farmers to become more self-reliant and make extension services more sustainable.

This work was ongoing at the end of the RFLDC in 2013. As described in Chapter 5, since 2013 RFLDC and CDSP IV have sought to integrate aquaculture and livestock extension activities into the latter's Social and Livelihood Development Component. A technical staff appointment was made in support of the livestock sector and the possibility of integrating the NGO groups on credit and savings and the Water Management Groups with the CBOs appeared promising. However, the different institutional framework and mode for farmer training was identified as a problem. Sustainability also requires changes at policy level, particularly through enlisting the private sector in production of young animals and vaccine, if the appropriate environment for livestock development is to be created.

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Chapter 7

Water, Soils and Crops

Sk. Md. Abdus Sattar Ph.D.

7.1 INTRODUCTION

This chapter deals with the agricultural development in chars in southern Noakhali, in particular the areas covered by the first, second and third phase of the CDSP-project. Productive potentials of the three polders in Noakhali– Char Baggar Dona, Char Bhatir Tek and Char Majid — were explored in CDSP I. Efforts continued in the second phase in extended areas of seven chars in Noakhali, Feni and Chittagong districts. One of the major shifts in this phase was to move beyond the protected areas to some unprotected chars as well. In the third phase work continued in an initially unprotected char, Boyer Char, which would eventually be made into a polder during the project period.

Especially during the second phase of the project, coastal ecosystems were analyzed in greater detail in order to find out which available agricultural technologies most suited the ecosystems concerned. Ecosystems largely determine what type of agricultural production is possible in a practically unexplored, virgin area. Key elements in the system for crop production are the availability of water and characteristics of the soil.

The chapter starts with the question of water availability (7.2) and continues with the quality of the soils (7.3). They influence the crop production of an area, which is the subject of 7.4 Agricultural zoning and extension strategies (7.5), and strategies for the future (7.6) conclude the chapter.

7.2 AVAILABILITY OF WATER FOR AGRICULTURE

7.2.1 Surface Water Resources

As we will see in 7.2.2, fresh water required for agricultural production is scarce in coastal ecosystems. Sources of fresh water in the coastal region are direct rainfall and rainwater stored in open water bodies like canals, ponds and ditches, and borrow pits. Water in the Meghna estuary itself changes in salinity over the year, with high salinity in winter to practically non-salinity in monsoon time, when the huge discharge of river water pushes the front of saline water to the south, beyond Hatiya island.

Rainfall Characteristics

The amount of precipitation and its distribution in a particular location or region determine crops and cropping patterns. The southeastern coastal region (Lakshmipur/Noakhali/Feni area) receives more rain annually than the south central (Barisal) and south-western (Khulna) part of the coastal zone. The total amount of annual rainfall is high, usually it exceeds 3,000 mm in the southeastern coastal region, while in the western region it is below 2,500 mm (Figure 7.1). The distribution, in most cases, follows however the same pattern. Most rainfall occurs during monsoon (June to September) all over the country but late rain (until October and into November) is a common feature of the coastal region. The cropping seasons are largely determined by the pattern of rainfall distribution as is clearly shown in Figure 7.2 The country has three cropping seasons: *Kharif I* or *aus* (March to June), *Kharif II* or *aman* (July to November) and *rabi* (December to March/April).

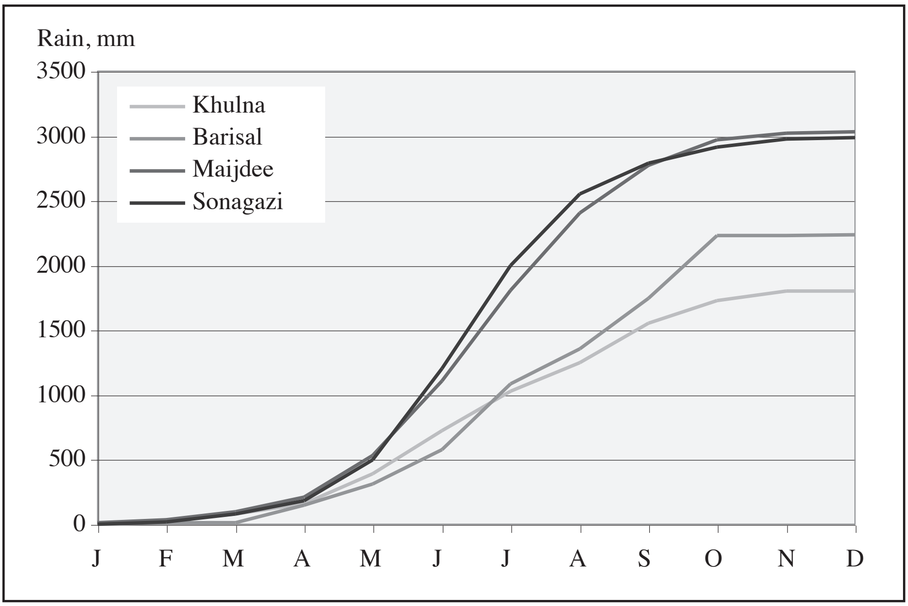

Figure 7.1: Cumulative Rainfall at Four Coastal Locations

Availability of Surface Water

Rain and/or tidal water (which is non-saline in summer) stored in the open water bodies are good sources of water for agriculture in the coastal region. This water is sometimes used for irrigating crops, for limited areas. Although at the end of the monsoon most of these water bodies remain filled with water, only a small amount of water becomes available for irrigation as the water bodies dry up or contain little amount of water by March-April, the time when *rabi* crops demand irrigation water.

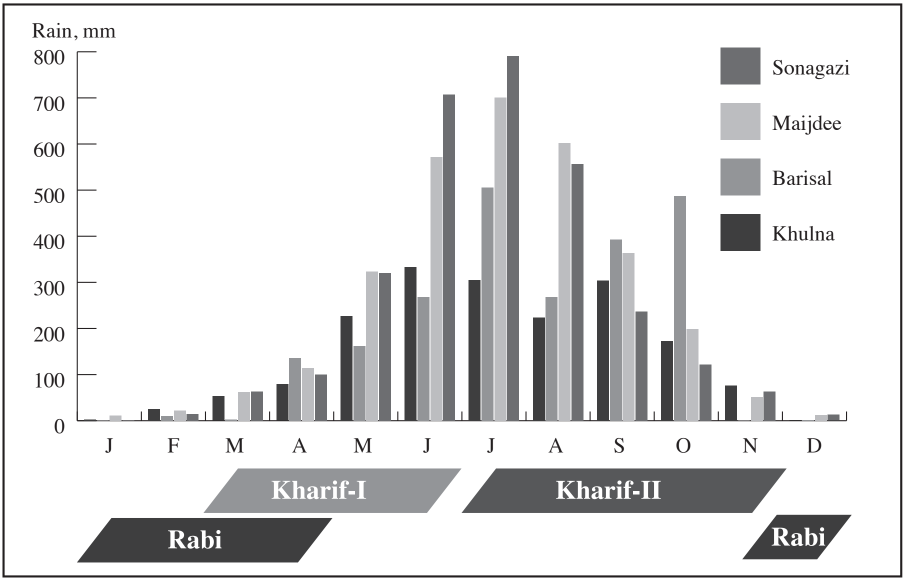

Figure 7.2: Monthly Total Rainfall at Four Coastal Locations and its Relation with the Cropping Seasons

Almost every house has a pond or ditch, the dimensions vary considerably among the households. The average size of the seasonal ponds is about 0.08 ha. Many ponds are the borrow-pits for making raised platforms to build houses on. Pond water is used mainly for domestic purposes and for aquaculture (see Chapter 5). As a source of irrigation water, these ponds are not significant. If water is used for irrigation, it is mostly for non-rice *rabi* crops in homestead areas and fields covering small pieces of land near the pond. In addition to the ponds, limited amounts of water from borrow pits and canals are available for the irrigation of small vegetable fields and seedbeds.

There is a scope to increase the volume of fresh-water storage in the coastal region by (a) increasing the depth of the ponds owned by the farmers, (b) stopping leakages of the sluices and maintaining these properly, (c) keeping the main canals of the area filled up with fresh water during the post-monsoon period through proper regulatory devices, and (d) promoting the construction of more community-based multipurpose larger ponds on *khas* land. However, storing more water in the canals has its limitations. Firstly, the sluices have to be kept open until early October to allow drainage that facilitates harvesting of the standing *aman* crop. Secondly, the outside canal or river water starts becoming saline in October thereby reducing the chance of flowing of fresh water into the canal (see Figure 7.3).

Besides increasing the storage capacity of water in ponds, canals and borrow-pits, the quality of water should be taken into account when water is used for irrigation. A survey showed that water of most ponds of the Noakhali coastal chars appears to be sweet, especially in the already protected areas. The water in ponds ranged from 0.18 to 2.18 dS/m. The permissible limit of salinity of the irrigation water is generally considered to be 0.7 dS/m.

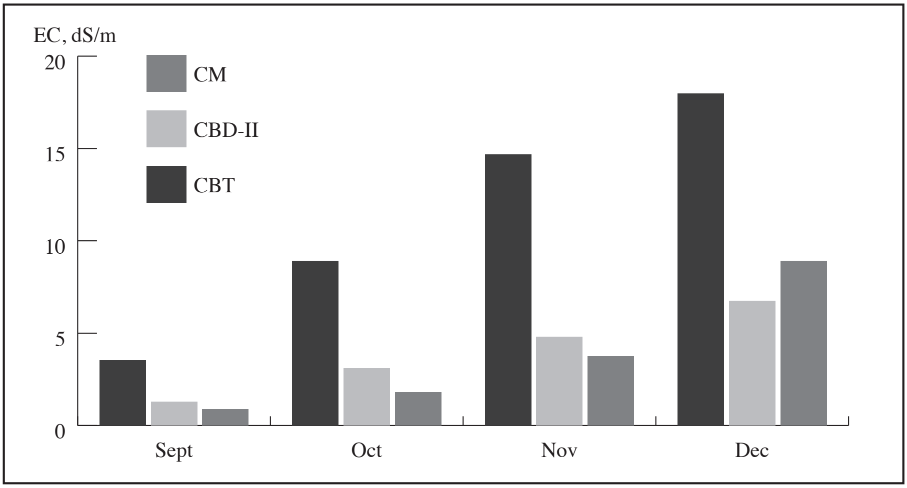

Figure 7.3: Maximum Salinity of Canal Water Outside Sluices (Sea Side) of Three Polders of CDSP I

Flooding Characteristics

Two types of flood occur in the coastal area — (a) flooding caused by monsoon rain which cannot drain into the rivers or takes longer time to drain due to obstructions in the drainage canals, and (b) tidal flooding during high tide or storm surges associated with cyclones.

Seasonal flash floods occur after heavy downpour during the monsoon, the depth varies per location, depending on elevation, from 12 cm to 167 cm (Table 7.1). During monsoon the canals in some areas usually remain filled up with rainwater that cannot recede because of the raised water level in the nearby larger water bodies to which it drains, combined with a very low seepage and percolation rate. This, together with an elevated

Table 7.1 Ranges of Peak Monsoon Flooding Depth At Project Locations Reported by Farmers

Locations	Ranges (cm)
Moradona	30
Char Lakshmi	15
Gangchil-Torabali	10
South Hatiya	12
Bandartila	10
Nijhum Dwip	12-90

foreshore of some of the areas, impedes rapid drainage and prolongs the duration of water stagnation until late December.

Because of the higher monsoon rain, fields in the coastal region remain flooded with rainwater up to an average depth of 30 cm in the early monsoon period. But most farmers keep the height of the field levees much higher to impound more water (up to 50 cm or more).

Coastal areas experience a daily cycle of low and high tide. The medium to lowlands of the unprotected areas are occasionally flooded with tidal water which remains non-saline during Kharif-II season. In the Noakhali chars, the depth of such flooding normally varies from 3 m to 4 m above the mean sea level during monsoon. Such flooding occurs twice a day. The frequency of real devastating tidal flooding of the crop fields varies considerably with the land type and proximity of the areas to the coast.

Drainage Problems

The coastal region is an accreted and almost flat area just 2.2 m to 5.0 m above the mean sea level. Although the elevation of the northern parts of the country is higher than that of the southern areas, allowing easy drainage of the main rivers, many of the southeastern areas of the country closer to the coast have a serious problem of water congestion. This is mainly due to the impeded drainage as a result of siltation of the canals, particularly of the secondary and tertiary ones. Sedimentation along the coast (see Chapter 2) has resulted in an elevated foreshore. The effect of the general slope of the country becomes almost non-existing in the immediate vicinity of the coast. Although flat lands dominate the region, localized depressed areas, behind the coastline, are common. For these low-lying fields, separate cropping patterns should be applied and a combination of fisheries and rice cultivation (see Chapter 5), should be considered. Also, community-based aquaculture without rice, as is practiced in waterlogged areas in the center of Noakhali District, is an option.

7.2.2 Ground Water Resources

Extraction of groundwater for agricultural use in the coastal saline ecosystems is restricted due to possible intrusion of saline water in the groundwater aquifer. Serious groundwater surveys have actually never been carried out in the coastal zone. Empirical evidence from drilling of tube wells for drinking water shows that shallow aquifers are scattered and erratic in shape, while water is in many cases too saline for irrigation. Sweet water is found in the char areas on a depth of over 300 meters. But the impact of extracting water from such deep aquifers on the intrusion of saline sea water is not known. It also turned out that water from deep layers contains boron in a relatively high concentration. That is why the Government imposed an embargo on extraction of groundwater for irrigation in the coastal region. Moreover, the huge costs involved would make it economically not attractive. Also, deep layers of sweet water are important for drinking water supply.

With a view of the limited knowledge that is available at present, it is recommended to undertake a hydro-geological study into the availability of fresh ground water in the Greater Noakhali area. The recharge characteristics of the aquifers and the risk of salinization should be major subjects in such a study.

7.2.3 Potential for Irrigation

Normally there are two sources of irrigation water, surface water stored in open water bodies such as ponds, ditches, borrow-pits and canals, and sub-surface or groundwater. As we have seen, ground water is not an option, which only leaves stored water as a possible irrigation water source.

For the *aman* rice crop, there is no need for irrigation of the rice crops, because of the abundance of rainfall. A rice crop during the *rabi* season is just not possible because of the limited amount of fresh water that could be tapped. One has to bear in mind that in winter, the water in the Meghna estuary is saline, because of the reduced discharge from the river systems.

Paddy fields along the coast remain muddy until late December which delays harvesting of the *aman* rice as well as planting of the next non-rice *rabi* crops. Soils remain wet for quite a long time. *Rabi* crops planted in these soils seldom die but have restricted growth due to drought later on. In March and April some irrigation is required before the rain starts for optimum performance of these *rabi* crops. Possibilities for irrigation are constrained because of the limited amount of water stored in canals, ponds and ditches. But also because in many cases leakages of not well maintained sluice gates cause saline water to enter into the canals during spring tide making the water unsuitable for irrigation.

Diverting fresh water from a distant source to the south-eastern part of the country would be a potential solution for the seasonal water shortages in the char areas. But the massive costs involved, as well as the complicated engineering and social issues, makes this option probably prohibitive.

7.3 SOILS OF THE COASTAL CHARS

7.3.1 Physical Conditions and Fertility of Soils

The Noakhali coastal region, part of the Young Meghna Estuarine Floodplain, represents Agro Ecological Zone 18 (see Chapter 6). Coastal chars are formed as a result of alluvial deposition of silt and clay. The soils are young without differentiated horizons, stratified grey and calcareous. Soils are mostly heavy textured varying from silty clay loam to silty clay and are almost devoid of sand. Soils of relatively newer chars are dominated by clay, while those of older ones have more silt. Such soil texture is characterized by having a high moisture retention capacity. The soil moisture is at 50 volume % with a groundwater table at 1 m. Further downward movement of the water table to 3 m only results in a decrease of the equilibrium of moisture retention to 30 — 40%. Upward movement of moisture due to evaporation, will usually exceed downward movement due to a decreasing water table. This results in salt accumulation in the topsoil in the dry season, unless the evaporation is reduced by special measures, such as tillage and mulch cover. Figure 7.4 gives the soil moisture in different layers during the *rabi* season, from the end of December till the beginning of April.

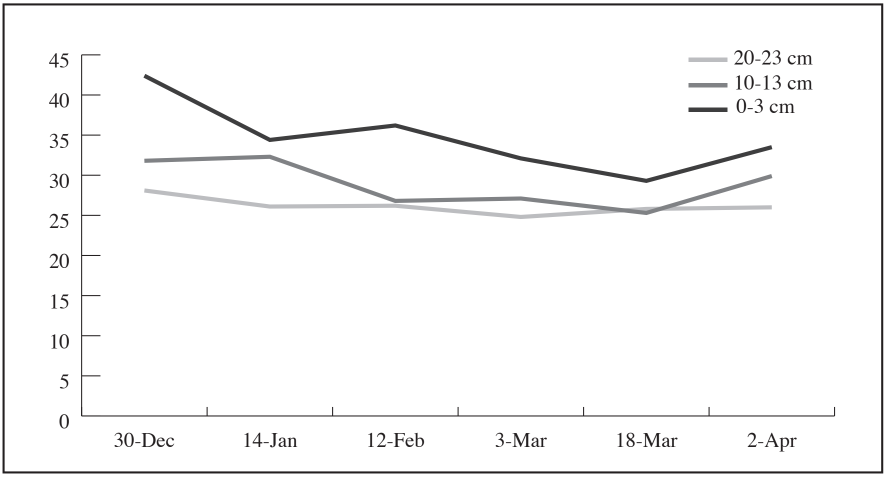

Figure 7.4: Soil Moisture(%) in Three Layers after Harvest of Aman Rice at Char Majid and Mora Dona (Mean of Six Fields)

The young landmass formed in the coastal chars develops slowly into productive soils through addition of organic matter. The organic matter content of soils of the southeastern region is low, ranging from 0.86 to 2.44% in the topsoil and from 0.93 to 2.02% in the subsoil. The soil reaction in the top soils is mostly near neutral to slightly alkaline (pH ranges from 7.0 to 8.8) while sub-soils are mostly alkaline (pH = 7.5 to 8.8). Induced nutritional imbalances often occur in such soils, particularly of zinc and phosphorus. Analysis of soil samples from the CDSP-II chars indicates that the coastal char lands are mostly deficient in phosphorus, while deficiency of zinc was found in only small patches scattered over the area. Deficiency of nitrogen is almost a worldwide problem and is a major concern of every farming community. All other elements are abundant or present in excess of the sufficiency level, particularly sulfur, magnesium, calcium, manganese, iron and boron (Table 7.2).

Sulfur and zinc, even when present in large quantities, may exhibit induced deficiency due to the alkaline soil reaction. Therefore, proper management of soil salinity and, in some places, supply of nitrogen, phosphorus and zinc are required to produce crops successfully in the coastal region.

Table 7.2 Nutritional Status of the Coastal Soils in CDSP Areas

Nutrients	Range	Mean	Critical	Optimum
Total N (%)	0.04-0.11	0.06	0.12	0.27

7.3.2 Soil Salinity

Soil salinity is one of the major factors determining land use and land productivity in the coastal areas. Soil salinity and its annual cycle, spatial variation and long-term trend, determine the type of agricultural production systems in the coastal region.

Spatial Variation

Large spatial variation in soil salinity exists even within the same plot as is indicated by high standard deviations (Table 7.3; measurements from 2001). Values in the last column give the standard deviations. In a homogeneous population these values are very small, usually less than one. But in Table 7.3 values are high, indicating that the values of the samples from a single plot vary considerably or, in other words, that the spatial variation is high. The reasons of such variation is not exactly known but are thought to be associated with the presence of the perched water table located at shallow depth, impeded drainage and/or very slow seepage, and the kind of soil management being practiced by farmers. Because of the high degree of spatial variation at any location, knowledge of the ranges of soil salinity rather than its average values is important for designing land use planning of an area. This would actually require grid-based baseline data on soil salinity before recommendations on agricultural patterns can be formulated.

Table 7.3 Soil Salinity (ECe, dS/m) in the Top-Soils (0-10cm Layer) of Six Chars Measured in March-April

Chars	No. of sample	Range	Mean	Optimum
MD	69	2.9-60.7	31.0	17.0

Annual Cycle

The level of soil salinity is dynamic and shows an annual cycle, changing with the seasonal wetting and drying process of the soil. The maximum salinity occurs when the soil becomes dry in the months of March and April (Figure 7.5). The salt comes up along with the rising capillary water that is evaporated, leaving behind the salt on the soil surface. This continuous pulling up of ground water increases salinity in the topsoil and this process continues until monsoon rains starts in late May or June.

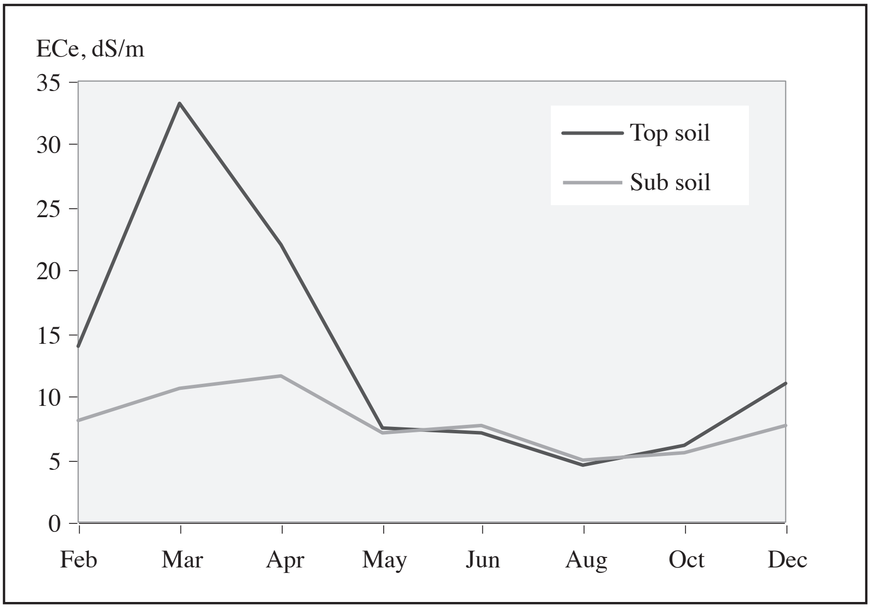

Figure 7.5: Annual Cycle of Soil Salinity (Average of Seven Chars)

Rise in soil salinity starts in late October or November and is related directly to the drying pattern of the soil. Late rain in October in the southeastern coastal region is a blessing as it delays soil drying and thus retards development of soil salinity until February.

Trend in Soil Salinity

In addition to the annual cycle, a long term downward trend in soil salinity is expected after protection of the chars as the salt is thought to be washed away gradually from the land. Leaching out of the topsoil in the monsoon season is a well-established fact, less clear is how the mechanisms exactly works. It was earlier assumed that deep drainage was the main reason causing removal of salts, but this applies probably much more to land with higher elevation than to low-lying areas as the chars of Noakhali. The thinking now is that other factors are at play, such as the speed of surface drainage of rain water, the permeability of the soil, the amount of leakage of sluices and the type of management given to soil for various land usages. The desalinization process goes slowly, with annual variations in the long term downwards trend. For all protected areas in CDSP where soil salinity is measured, there is a rather steep reduction in the first years, a re-emergence of higher levels in the years after, and subsequently a decrease again. The trend, however, shows some volatility. The general trend matches with the perceptions of the aged farmers of the locality who say that soil salinity reduced to a safe level for crop production after about 8 to 10 years after the complete protection of the area from saline flooding.

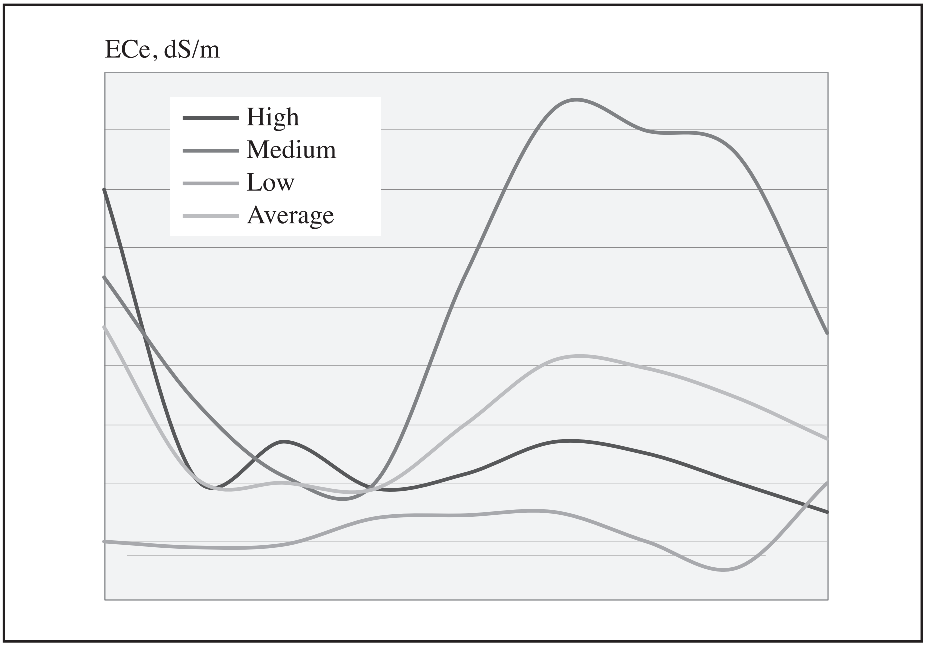

Figure 7.6: Soil Salinity in March/April at Char Majid

Figure 7.6 shows the development of soil salinity in Char Majid (protected in 1998) at three fields with high, medium and low levels of soil salinity identified from the baseline soil salinity data. Also the average value is depicted. Samples were taken at each location from two depths (0-10 cm and 10-30 cm). Over the years, the average soil salinity shows a downward trend until 2003 followed by an increase to about 8 dS/m in 2004, and then had a declining trend until 2008. Since then the project discontinued monitoring soil salinity. The soil salinity in unprotected chars shows no clear development as yet. There are differences between chars depending on their location, with more inland lying chars showing a greater tendency towards decreased soil salinity. All have high annual fluctuations. As perceived by the farmers, cultivation of crops and application of manure coupled with flushing of the area with rain water, enhance reduction of soil salinity.

A contribution to the solution of the salinity problem would probably be to postpone protection of new land by embankments until the accreted area has reached a sufficient topographic height to allow for natural drainage. The determination of that level has been dealt with in Chapter 3.

7.4 AGRICULTURAL DEVELOPMENT

The principal land use in the coastal region is crop production, in particular in the protected areas. There is obviously much scope for other forms of land use such as fisheries and livestock farming (see Chapters 5 and 6).

7.4.1 Crop Seasons

There are three crop seasons in the country — Rabi, *Kharif I* and *Kharif II* — classified mainly on the basis of annual distribution of rainfall (Figure 7.2) and temperature. *Rabi* covers the whole dry period of the year from November to April. Farther from the coast, the *rabi* season shows an overlap with the later part of *Kharif II*. Some *rabi* crops which are not very sensitive to temperature are planted in the second half of August and September. In the coastal region the *rabi* season starts a little late, in the month of December or later, due to slow drying of the land. The *Kharif II* season covers the whole monsoon season and is characterized by high temperature and high rainfall. The season begins in July and ends in December. The *Kharif I* season is sandwiched between *rabi* and *Kharif II* and covers the period of March/April to June/July.

The interventions for an increase in crop production are aimed at achieving (a) higher cropping intensity through the introduction and or of *rabi* crops and increasing coverage of *aus* (kharif-I) crop (see section 7.4.2); (b) more crop yield per unit area through replacement of the traditional varieties with high yielding (HYV) ones (see section 7.4.3 and 7.4.4); and (c) promoting improved techniques of crop production (see section 7.4.5).

7.4.2 Cropping Patterns and Cropping Intensity

The types of crop grown vary considerably among the seasons. During the pre-CDSP period all the project areas were dominated by single cropping of transplanted *aman* (*Kharif II*) rice. Only a small fraction of land was used to grow either direct seeded or dibbled *aus* rice or a few *rabi* crops. Table 7.4 shows the change in cropping patterns in two chars of CDSP II from the pre-project period to the post-project period. It also indicates the increase in cropping intensity from about 116 to 150 in Char Mora Dona (unprotected area) and from 114 to 181 in South Hatiya, an area that was protected under CDSP. This increase was attributed to the conversion of single cropped area, particularly transplanted *aman* rice, to double cropping of *aman* rice and a variety of *rabi* crops. The increase of area under *aus-aman* pattern is very small (about 3 to 5%). The area under triple cropping pattern of *aus-aman-rabi* varied from about 9 to 22%.

Table 7.4 Cropping Patterns and Changes in % Area Under Each Pattern in Two Chars of CDSP II during Pre– and Post-Project Periods

Cropping pattern	Pre-project (2000)		Post-project (2004)	
	MD	SH	MD	SH
Aus	0.0	0.96	0.0	0.0
Aman	98.18	88.24	57.4	40.1
Rabi	15.67	0.01	0.2	0.4
Total	**113.85**	**89.21**	**57.6**	**40.5**

Continued

Table 7.4 Continued

Cropping pattern	Pre-project (2000)		Post-project (2004)	
	MD	SH	MD	SH
Aus-aman	0.23	1.23	3.0	4.6
Aus-rabi	0.06	0.05	0.1	0.1
Aman-rabi	1.54	21.75	30.6	32.2
Total	**1.83**	**23.03**	**33.7**	**36.9**
Aus-aman-rabi	0.03	1.76	8.7	22.2
Cropping intensity	115.71	114.0	151.1	180.9

For all CDSP II areas combined, the cropping intensity rose further to more than 200% in 2009. If the average situation in CDSP I and II areas combined in the year 2001 is compared to 2009, 70% of single crop turned into 30%, 22% double crop into 40% and 8% triple crop into 30%. Monitoring of cropping intensity continued until 2016. The cropping intensity shows a slight declining trend during 2012 to 2016 in all the areas (Figure 7.7), perhaps due to annual variations in the climatic conditions.

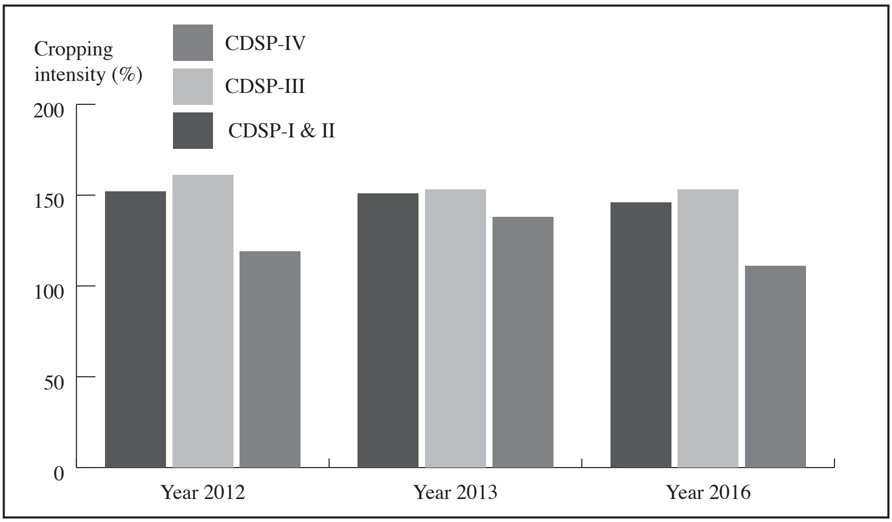

Figure 7.7: Changes in Cropping Intensity

7.4.3 Adoption of Modern Crop Varieties

Growth in HYV Adoption

A part of the overall increase in crop production was due to the shift from local varieties to HYV. The improved extension program certainly contributed to this change in crop choices. Through training, field demonstrations and motivational tours, the farmers were gradually convinced that high yielding varieties could substantially contribute to a better livelihood. The improved water management conditions in empoldered areas further facilitated the adoption of HYV crops. The greater risks involved and the non-availability of required inputs as seeds and fertilizer, were obstacles in this adoption process.

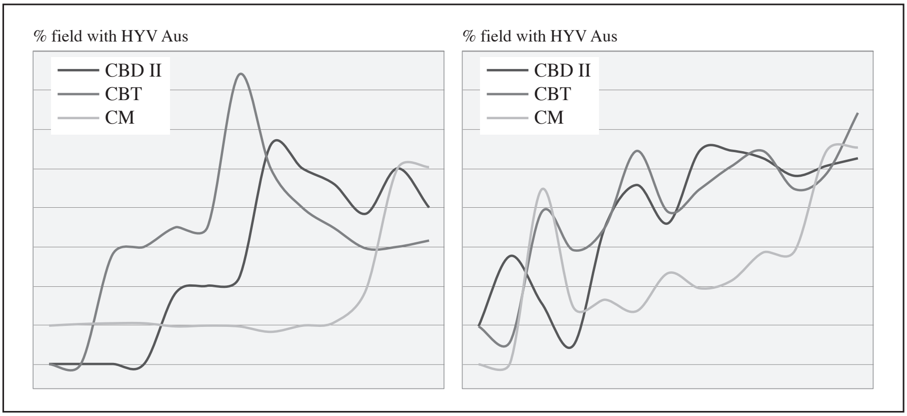

Figure 7.8: Adoption of HYV Rice in CDSP-I Polders

The, rather erratic, changes over the years in use of HYV rice are shown for three CDSP I areas (all protected by the project) for the *aus* and *aman* seasons (Figure 7.8). When averaged over three polders, adoption of HYV *aus* rice increased from about 2 to 23% and that of *aman* rice increased from about 4 to 30% (Figure 7.9).

The main crops involved are reflected in the list below. It gives the specific local or HYV crop in order of preference by the farmers. A limited number of farmers grow HYV *boro* rice in winter, using surface water for irrigation from nearby canals or borrow pits wherever available.

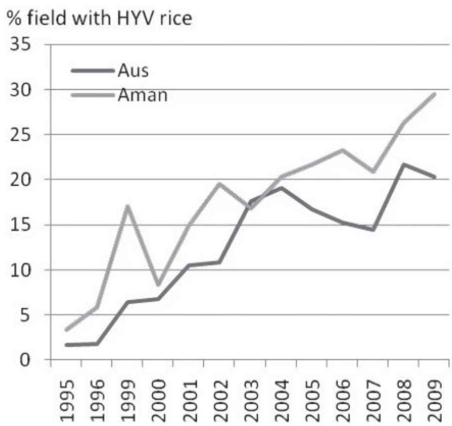

Figure 7.9: Adoption of HYV Rice by Crops
(average of CDSP-I Polders)

Causes of Non-Adoption of HYV in Coastal Chars

There are a number of reasons that lead farmers to decide not to opt for a HYV crop:

- The risk of damage to the seedlings is higher than with traditional varieties, because the HYV seedlings are shorter in height; newly planted *aman* crop goes under water more quickly after heavy monsoon rains.
- Most HYVs have a low tolerance for soil- and water salinity.
- Many local farmers prefer coarse grained rice, while most HYVs give medium grains, which has a lower market price; farmers have to be convinced that the higher yields outweigh the lower price.
- Many of the HYVs are late maturing, while farmers prefer early maturing varieties; there are now early maturing HYVs available.
- Farmers have to invest more in HYV crops, because they demand more fertilizer and more intensive weed control; local varieties are mostly grown without fertilizer.
- The planting time of local varieties is more flexible as they are strongly sensitive to photo period; HYVs are either insensitive or have a low sensitivity.

List of Crops Adopted (arranged in Preference of the Farmers)

Crop	Local variety (DSR)	HYV/New *rabi* crops
Aus DSR	Hashikolmi	BR21, BR1, BR14
	Kerandol	BRRI Dhan27
	Boilam	BRRI Dhan42
		BR9 (Dayal IRRI)
		Purbachi
		Sonali IRRI
Aman	Rajasail	BR11, 22 and 23
	Kajalsail	BRRI Dhan39
	Gigaj	BRRI Dhan40
	Betichikon	BRRI Dhan41
Rabi	Khesari,	Watermelon(HYV)
	Chilli	Okra (HYV)
	Sweet potato,	Soybean (HYV)
	Linseed, Felon, Groundnut,	Groundnut (HYV),
	Egg plant	Sweet gourd
	Tomato, Mungbean	Tomato (HYV)

7.4.4 Crop Yields

The quality of the on-field management of farmers is directly reflected in the crop yields. Management includes elements as selection of an appropriate variety of crops, the time and method of planting, nutrient management, weed management, and control of insect pest and diseases. Special techniques of soil and field management are required for managing soil salinity in the coastal region in order to make crop diversification as well as higher crop yield possible. CDSP motivated farmers to adopt these management practices that resulted in higher cropping intensity, the adoption of new high value crops, and higher crop yields.

Table 7.5 provides data on the development of crop yields from the pre– to the post-project period in the overall CDSP I and II areas. During the pre-project period local *aus* rice was grown in relatively less saline or non-saline soils and better yields were obtained as compared to the post-project period when crops were grown in both non-saline and saline soils. HYV *aus* rice was introduced which has about a 2 ton/ha yield advantage over the local varieties. Farmers usually take less care of their local varieties in *aman* season resulting in no improvement in yield. But, HYV rice grown in *aman* season has about a 1 ton/ha yield advantage. Initially about 80-90% of the land remained fallow during the *rabi* season. Sweet potato, chilli and groundnut were traditionally grown. After the successful introduction of some high yielding crops, the productivity in the *rabi* season was greatly enhanced. Watermelon, okra, sweet gourd and cucumber are grown commercially due to their higher returns and the much improved linkages with markets.

7.4.5 Techniques of Crop Production in a Saline Ecosystem

Based on experience throughout the several phases of CDSP, certain agronomic practices and techniques of crop production can be identified that are particularly suited to the prevalent saline ecosystem. This paragraph gives a brief overview.

Table 7.5 Mean Yield of Crops (kg/ha) during Pre– and Post- Project Periods

Crop	Variety	Yield, kg/ha	
		Pre-project	Post-project
Aus	Local DSR HYV (TPR)	1,820 -	1,620 3,600
Transplanted *Aman*	Local HYV Fine rice	2,106 3,107 1,022	2,320 4,089 1,993

Continued

Table 7.5 Continued

Crop	Variety	Yield, kg/ha	
		Pre-project	Post-project
Rabi	Groundnut	1,150	2,550
	Chilli (green)	4,400	6,810
	Sweet potato	12,330	16,800
	Watermelon	-	29,030
	Maize	-	2,495
	Felon	-	1,000
	Tomato	-	15,000
	Mungbean	-	1,000
	Okra	-	6,100
	Cucumber (Khira)	-	12,200
	Garlic	-	3,300
	Onion	-	6,500
	Potato	-	19,200
	Soybean	-	1,587
	Sweet gourd	-	15,800

Choice of Crops

Given the specific characteristics of the soil in coastal areas, including its salinity (see section 7.3), the choice of crops is crucial. CDSP tried to identify crops with tolerance to soil salinity, especially with regard to *rabi* crops.

Table 7.6 Tentative Tolerance of Field Crops to Top-Soil Salinity, Measured during the *Rabi* Season

Range of ECe (April value)			
< 8	8 - 16	16 - 30	> 30
Sunflower Soybean Wheat Cowpea Mungbean Okra Watermelon	*Aus* Groundnut Lineed Garlic	Chili Sweet Potato Greengram Batisak	No *Aus*, No *Rabi*

Seeds of most common *rabi* crops do not germinate in case the initial salinity level (EC) exceeds 12 dS/m. Crops that survived the germination period well and showed good growth in soil of a salinity level of 5.2 initially, rising to 18.6 at the time of harvesting, were: batisak, triticale, sunflower, cheena, spinach, greengram, kangkong and china sak. Batisak appeared to be highly tolerant, since it survived a final EC level of 38.6 (see Table 7.6).

Sowing of *aus* paddy coincides with the peak of soil salinity (March-April) and consequently failure of the crop is not uncommon. On the basis of field tests in the chars, the conclusion can be drawn that the threshold for growing an *aus* rice crop is 15 dS/m EC. The BRRI Dhan 27 variety performed the best among the tested varieties.

Due to monsoon rains, the salinity level in the *aman* season is usually not an issue. Still, sometimes the rice crop is affected by soil salinity, in particular during a short dry spell in the monsoon.

Dry Seedbed for Aus

The soil salinity reaches its highest peak during March-April, the time of the preparation of the seedbed for transplanted *aus* rice. During this period, surface soil may become dry in many places. Because of the high soil salinity and the lack of adequate moisture in the surface soil, farmers of the coastal areas are not in a position to prepare the conventional type of seedbed. They have to push the seeds deep into the sub-surface layer, where soil salinity is relatively low and the soil is sufficiently moist. They prepare a seedbed after dry tillage and dibble seeds in a lump of 30 to 40 seeds per hole. Normally, seedbeds are not irrigated due to a lack of irrigation facilities.

There are several advantages and disadvantages of the dry seed bed method.

Advantages are: germination of seed is ensured due to favorable microenvironment of the sub-surface layer; since the seedlings grow in a lump, greater strength is offered during uprooting which prevent seedlings from breaking or tearing off; because the root system is developed in a deeper layer, the seedlings can extract more water and can survive a short spell of drought. However, there are disadvantage as well: owing to overcrowding in the seedbed, individual seedlings might be weak; such dry seedbeds require more costs and labor; in case rainfall fails to come, uprooting of seedlings becomes difficult and they are likely to break when they are pulled out.

Raised Seedbed

Elevated seedbeds have the advantage that the transported top soil becomes non-saline because salt is washed out during the monsoon season and because the upward movement of salt is disrupted due to the increased distance from the groundwater table and because of the breaking of capillary tubes. *Rabi* crops or their seedbeds can be prepared on such raised beds. These could be specially made beds, or small roads to the homestead can be partly used as seedbed.

Cultural Techniques

After the harvest of *aman* rice, land remains fallow for some time, in some cases even up to a few months. During this period soils start drying, resulting in capillary rise of groundwater which brings up salts that are deposited on the soil surface. Any intervention that disrupts capillary rise will minimize the loss of residual soil moisture as well as soil salinity. Among the various methods used to conserve residual soil moisture and reduce soil salinity, are dry tillage during the inter-phase between *aman* and rabi, and mulching with crop residues. Especially in areas of the coastal region where soil starts drying early, this technique helps to grow *rabi* crops like potato, watermelon, cucumber etc.

Drip or Ring Irrigation

Keeping surface soil moist will check capillary rise. Crops grown with wider spacing or planted in wider rows can conveniently be irrigated following the concept of drip irrigation, so that at least the base of the plant can constantly be kept moist. However, care should be taken that sufficient water is applied to allow percolation beyond the root zone. This technique can be considered in case of high value crops, like the various types of gourds, tomatoes and water melon.

Sorjan

Sorjan is a system of rice-fish culture developed and practiced in Indonesia to increase farm productivity. The system was modified IRRI Bangladesh office by replacing rice with vegetables by and was introduced with great success in Patuakhlai and Khulna coastal districts of Bangladesh to increase total farm productivity. This system of vegetables-cum fish production was introduced especially in areas of the last phase of CDSP and is gradually gaining popularity. It is a system where vegetables are cultivated on ridges, with fish in the ditches between them (with water for six to eight months). It is estimated that about 10% of the households in CDSP IV areas practice this technique. Some farmers have abandoned rice growing altogether, exclusively adopting the *sorjan* method, selling fish and vegetables to and buying rice from the market.

7.4.6 Agriculture and Livelihoods in the Chars

Crop production, fisheries and livestock are the most important economic activities in the chars of southeastern Bangladesh. Crops are dominant in the polders, while in unprotected areas, fisheries and especially livestock, often have the upper hand. Industrial establishments are hardly present and the service sector is still in its infancy, but higher productivity in crops and better communications has led to more job opportunities in a range of services. However, landless households that receive ownership of newly accreted *khas* land, do not receive more than 1.5 acre (about 0.6 hectare) per household (Chapter 8 deals with the land settlement issue). The question is whether a plot of that size is sufficient for a sustainable livelihood in the char environment. Surveys have indicated that this is not the case. In CDSP areas, the percentage of the population with food shortages decreased from 40% to 20%. This is an encouraging result, but it means that still one in every five families face food problems, despite the fact they received a title on land.

7.5 STRATEGIES FOR AGRICULTURAL EXTENSION

7.5.1 DAE Policy and Strategy

The extension with regard to agricultural development is the responsibility of the Department of Agricultural Extension (DAE) under the Ministry of Agriculture. The policy is set out in the New Agricultural Extension Policy (NAEP) of 1996. It is however difficult if not impossible for DAE to implement the NAEP properly, for a variety of, often logistical, reasons. Even though the DAE staff were familiar with the participatory extension approaches, they failed to implement the recommendations laid down in the NAEP adequately for various reasons. Lack of staff and inadequate budgetary provisions leading to a shortage of transport, are the most important ones among them. Especially for an area known for its harsh conditions, these factors have a severe impact on the effectiveness of the extension services being offered. In the framework of a project, as CDSP, the constraints are mitigated and new strategies could be introduced.

7.5.2 New Approaches

CDSP introduced a new extension approach which proved reasonably effective. The extension was given a firm base through the identification of agricultural development zones. This made targeted messages possible, tailored to the situation in specific areas. Farmer Forums (FF) were established to focus the dialogue between farmers and the "service providers" as DAE. Much attention was given to demonstration plots, training, field days and motivational tours.

Land Zoning for Agriculture

As mentioned earlier, the Noakhali coastal region belongs to the Young Meghna Estuary Floodplain, and represents Agro Ecological Zone 18. The AEZ classification is, however, too broad to be useful for guidelines for cropping patterns and selection of crops. Conditions in the coastal chars are far from uniform, particularly in respect of soil salinity, soil texture and flooding depth. Variations exist over fairly short distances, which means that even areas in close proximity to each other, can have considerable differences in production potential. During the CDSP II period, an attempt was made to identify areas with the same level of productivity: the productivity zone (PDZ) concept. The aim was to assist farmers to predict the options in their particular location. If the actual farmer's practice was different this would indicate either flaws in the concept or other factors influencing land use, such as land tenure relations and the capacity to invest. In addition, the objective was to facilitate the extension services in targeting of technologies to particular areas.

The flooding depth and soil salinity were the two variables taken to identify a productivity zone. Maximum flooding depths were obtained by documenting the perception of the farmers during a plot-to-plot survey, supported by a subsequent verification during monsoon time. These maxima were used as a single factor characterizing overall field water conditions in that location. That is justified because monsoon flooding depth has implications for both monsoon and for *rabi* cropping, since it determines the start position of drainage of the field.

Soil salinity was measured when it reached the maximum level in March-April. Information on tolerance of several crops (rice, non-rice and vegetables) was generated through research. The result showed that reduction in growth of all crops was minimal as long as ECe of the topsoil (0-10 cm) was below 8 dS/cm. Above this level different crops reacted differently, according to their tolerance. Based on these results, four water regimes and four salinity classes were used. It must be kept in mind that salinity in the coastal chars is different from that in arid climates where the soil is permanently saline. In the coastal zone salinity builds up gradually after cessation of the rains, so a soil which has a fairly high salinity figure of, say, 12 dS/m would be unsuitable for most crops in arid lands, while in the coastal chars of Bangladesh this level of soil salinity is not static, rather fluctuates within a short span of time due to changes in soil moisture regime and thus, several crop species can still be profitably grown when 12 dS/m is the peak salinity measured in April.

By combining the factors, four different productivity zones were identified:

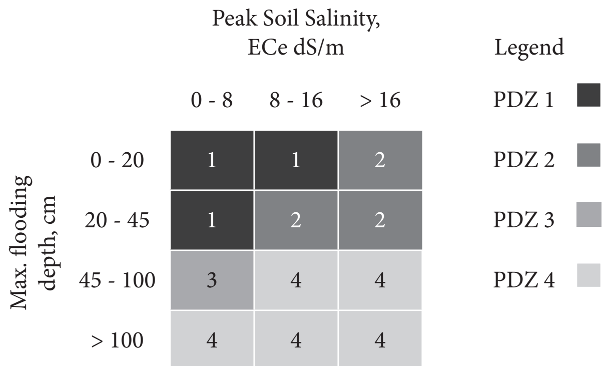

Figure 7.10: Identification of Productivity Zones

Flooding depth is the major factor for kharif-II (monsoon) cropping. Soil salinity has only a minor effect on *aman* paddy because the salt is pushed down below the rooting zone by the fresh water layer. For kharif-I (*aus* season) the major factor is the conditions at crop establishment, i.e., in April, when salinity is most severe. For *rabi* cropping the important factors are both salinity and water logging in early and late *rabi* season. Delayed drainage of deeply flooded fields delays *rabi* planting, while in the next pre-monsoon water from early rains may accumulate in low lying fields, damaging standing *rabi* crops.

Table 7.7 Production Zone Characteristics

Prod. Zone (PDZ)	Characteristics
PDZ 1	"Shallow flooding, low to medium salinity". Favorable conditions in all seasons • High to medium high land that may get temporarily inundated to a maximum depth of 45 cm; after rain drain fast, within a few hours to 3 days. The land starts drying during mid-October to mid-November, sometimes later. The Zone is relatively risk-free where all types of crops can be grown. • Direct-seeded dibbled *aus* rice can be grown successfully. • HYV *aman* varieties have potential, but late transplanted *aman* may suffer from drought during the reproductive stage in a drought year. • Different *aman* varieties may be needed for high and medium land • In highland *rabi* crops can be planted early, which allows them to escape salinity stress in April (up to 6 dS/m). They may suffer from water scarcity during establishment; particularly in years with minimum late rain.
PDZ 2	"Shallow flooding , medium to high salinity". Favorable *aman* season conditions, limitations for *aus* and *rabi* due to salinity • High land flooded up to 20 cm depth with high soil salinity and medium land flooded between 20 to 45 cm with medium salinity. Shallow flooded areas drain fast, usually within a few hours to 3 days after each rain and the medium flooded areas become dry in mid-November. • Transplanted *aus* rice can be grown in the medium land in this zone. • HYV *aman* varieties have potential, but late transplanted *aman* may suffer from drought during the reproductive stage unless there is late rain. • Different *aman* varieties may be needed for high and medium land • *Rabi* crops tolerant to moderate soil salinity can be grown early in the high lands and less tolerant ones adapted to late planting in the medium lands.
PDZ 3	"Medium to deep flooding, low salinity". Flooding depth limits options in all seasons, suitable for short season *rabi* crops • Medium-low to low areas with low salinity. Fields do not drain out until late November or early December. In the lowest fields water logging may extend to January when there is late rain, which is common in the southeastern coastal belt. • Transplanted *aus* rice is suitable if monsoon flooding is not too deep, otherwise *aman* transplanting will be hampered. • Currently available *aman* HYV are not suitable • Late planted *rabi* crops can be grown but there is a risk of water congestion at maturation • High and low beds (*Sorjan*) can be tried with crops like summer and winter vegetables.

Continued

Table 7.7 continued

Prod. Zone (PDZ)	Characteristics
PDZ 4	"Deep to very deep flooding". Only suitable for tall *aman* varieties, *boro* if water is available • Low to very low lying areas; similar hydrological conditions as PDZ 3, but a longer period of water logging after the monsoon • Tall varieties of transplanted *aman* rice is the only crop suited for this zone. In very deeply flooded areas even that may not be possible. *Boro* can be grown if surface water is available

Using the above procedures maps can be produced for each of the chars concerned, using GIS software. Two examples are given below in the PDZ-maps of Char Mora Dona and Boyer Char. To demonstrate the difference between the chars, the table in between the maps (Table 7.8) gives the area in each char under each of the four PDZs.

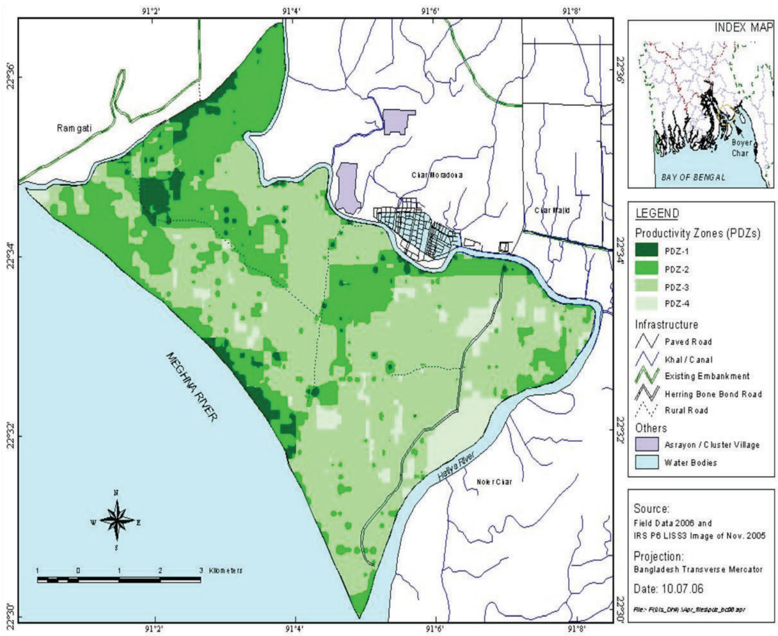

Figure 7.11: Productivity Zones of Boyer Char

The results of the application of the PDZ concept has been encouraging. Extension staff members of DAE find it easy to identify and locate areas with the same characteristics. A Technical Resource book, supporting the work with the PDZ concept, provides the technologies that are most suitable for any given set of parameters. The concept does not help the staff in their interface with the farmers during their dissemination efforts.

Table 7.8 Areas Under Each PDZ of Selected CDSP Chars; Figures in Parenthesis Are Percent of Cultivable Land

Char	PDZ-1	PDZ-2	PDZ-3	PDZ-4
Mora Dona	330 (22.5)	763 (51.9)	73 (5.0)	303 (20.6)
Char Lakshmi	29.0 (3.8)	39.3 (5.2)	51.2 (6.8)	633.2 (84.1)
Gangch.-T.Ali	143.0 (20.4)	2.0 (0.3)	101.0 (14.4)	455.0 (64.9)
South Hatiya	1153 (43.7)	450 (17.1)	102 (3.9)	931 (35.3)
Bhatir Tek	22.6 (3.4)	131.4 (19.8)	0.0 (0.0)	508.3 (76.7)
CO	92.0 (20.0)	95.0 (20.7)	22.0 (4.8)	251.0 (54.6)
Muh. Acc.Area	233.3 (15.1)	141.4 (9.1)	88.7 (5.7)	1085.0 (70.1)
Boyer Char	257.3 (4.6)	1700.9 (30.4)	3240.5 (58.0)	392.2 (7.0)

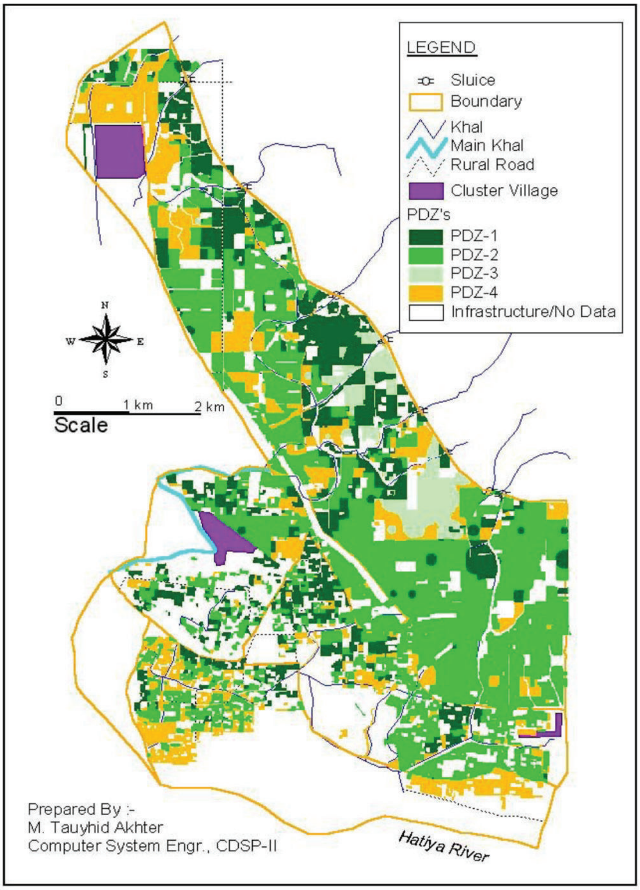

Figure 7.12: Productivity Zones of Mora Dona

Farmer Forum

The Farmer Forum is meant as a mechanism for dialogue and cooperation between agricultural producers in the coastal areas and "service providers" in agriculture, in particular DAE. It is not essentially different from the extension groups DAE is expected to set up according to its own extension policy. The forums should strengthen extension efforts by encouraging farmers to articulate their own needs for interventions to improve production. The number of farmers in a group is 25-30. Members of the Farmer Forum were selected per farmer-classes to make it a homogenous group following the criteria of (a) having at least 20 decimal of cultivable land, either of their own or rented in, (b) reside in or around the area and are socially accepted in the locality, and (c) are willing to participate in all group activities.

Members of the Farmer Forums meet regularly, once in two months. During the meetings, current field problems are discussed. DAE field level officers attend the meeting and assist the group to find solutions to the problems they face. They also take note of the unresolved issues and forward them to the Upazila Agricultural Officer who can include these in the agenda for the next meeting of the Upazila Agricultural Extension Coordination Committee.

Demonstration Plot

To make the demonstration more effective, the following guidelines were followed:

1. The details of the technology applied in the plot were discussed in the meeting of the Farmer Forum; farmers that showed great interest in the technology were given chance to establish a demo plot.
2. Fields that meet the ecological requirements for the technology are selected as demo plots.
3. The minimum size of the demonstration plot is 400 m2, located at a prominent place to attract the attention of the passers-by.
4. Farmers owning the demonstration plots, were motivated to test the technology by themselves. They invest their own labor and, if possible, in other required inputs. However, depending on the type of technology, DAE supports the farmer with some inputs like seed and fertilizer.

Farmer Training

The system of conventional classroom lectures was changed to a participatory dialogue to make the training program more effective. Farmer Forums are taking the organization of the training to a greater extent in their own hands. They identify the problem on which training is needed. The emphasis is on on-the-job training with a minimum of classroom type lectures. For further development of the training of farmers, experiences of the Farmer Field School type of approach in aquaculture and animal husbandry (see Chapters 5 and 6) should be assessed. Successful elements should be incorporated in the agricultural domain as well.

Field Day

In CDSP, field days were arranged directly in the field, close to the demo plot. The field day became more effective because the event was announced by a Forum member using a microphone in the area where the demo plot was established. It was arranged directly in or around the demo plot. Attending farmers had a chance to see the demonstration and exchanged views with the demo farmer and thus eliminated the need for the usual speeches delivered by extension staff.

Motivational Tour

The motivational tour by farmers proved to be an effective tool to convince farmers to adopt technologies that are unknown to them. This is particularly true in case of the coastal char dwellers who never move out of the region except for migrant labor. The tour helped them gaining confidence in certain technologies through the concept of "learning by seeing". Therefore, the motivational tour is a unique tool to expose the farmers to the modern agriculture and proved to be effective in creating awareness about modern technologies. Tours for farmers from the Noakhali chars have been organized, for example, to BRRI in Gazipur and to farmer fields in Bogra (variety of rice crops) and Comilla (*rabi* crops, especially vegetables).

Input Supply

Availability of agricultural inputs has always been limited in coastal areas, in particular in the southeastern region. There are a number of reasons for this situation: (a) farmers are not aware of the high input-based modern agricultural technologies, (b) modern crops and crop varieties were not adopted due to a host of socio-economic and coastal vulnerabilities, and (c) the infrastructure in the coastal region is not adequately developed and impedes people's mobility and the establishment of marketing facilities for agricultural inputs. All these led to no or poor demand for all agricultural inputs and hence no market for these products was developed.

CDSP supported char farmers, who were willing to produce and store HYV rice seed for selling among their neighboring farmers, with seed bins and hands-on training on production, processing and storing of the seeds. These farmers contributed significantly towards dissemination of HYV rice in the char areas.

Any external effort to strengthen input supply would take the whole extension effort one step further. As can be observed in older chars, shops where inputs can be procured are gradually being established. This is stimulated by the improvement of the road network and the growing demand from farmers.

Horticultural Nurseries

DAE established horticultural nurseries at the Upazila level only. These nurseries are good and reliable sources of saplings and seedlings for promoting social afforestation and homestead gardening. However, farmers of char areas seldom benefit from these nurseries, since these are located far away from their homesteads. Through CDSP, support was given to DAE to establish horticultural nurseries in the chars, which helped to diversify cropping and homestead plantations.

7.6 FUTURE STRATEGIES

Impact of Climate Change

Shorter and earlier winter seasons, more and more erratic rainfall, longer pre-monsoon drought periods and extended periods of flooding, as well as the greater risk of intrusion of saline water, are all climate change related developments that will have an impact on agriculture. A number of the strategies for the future reflected below, take these changes into account. Fresh water, soil salinity, salinity resistant crops and the quality of groundwater are all given attention in this concluding section.

Water Availability

As we have seen, the access to fresh water is a significant constraint on further development of crop agriculture in the coastal areas, especially those close to the shoreline like the chars in Noakhali. This situation could be eased by increasing the depth of privately owned ponds and by commissioning more large community ponds. It would also be worthwhile to investigate the possibility of transporting water from a distant source to the south-eastern part of the country. Both socio-economic benefits and the size of the required investments should be looked at.

O & M

A part of the fresh water problem is caused by flaws in the operation and maintenance of sluices. Leaking sluices lead to higher salinity of stored fresh water in winter time, causing damage to standing *rabi* and the germination of *aus* crops. While silted up drainage *khal*s impede the discharge of monsoon rain water in summer time, threatening the full growth of *aman* rice. Proper planning and implementation of O&M of water management infrastructure is obviously of crucial importance for agriculture.

Soil Salinity

Salinity of the soil is a second major constraint on higher crop productivity. A long term decrease of salinity can be observed, albeit with high annual fluctuations. This observation applies more so to the areas that are protected by embankments, than for unprotected land. When the decision is taken to go ahead with protection and turn unprotected land into a polder, the actual construction should be postponed until the accreted area has reached a sufficient topographic height to allow for natural drainage. This would contribute to the solution of the soil salinity issue.

Ground Water Survey

Little is known about the groundwater situation in the coastal zone. The impact of salinity intrusion by extracting groundwater is uncertain. It is really necessary to undertake an extensive groundwater survey of the coastal area, followed by a policy and strategy for groundwater use. Although large scale irrigation in spring and winter would probably under any circumstances be a responsible way to go, more knowledge could make limited irrigation warranted and could mitigate the feelings of uncertainty about installing deep tube wells for drinking water purposes.

Technology Generation

Crop varieties that are suitable for the saline environment in the coastal region and have attractive market values, would have substantial benefits for coastal communities. This would need research organizations that are capable of generating coastal friendly technologies. Over the last two decades, only a few such technologies have actually been developed. A constraint in this respect is that it is difficult to attract researchers to work at research stations that are located in coastal regions. The research institutes are not capable to offer the incentives to work in such, often remote and inhospitable, places. The problem could be addressed by entering into public/private partnerships in agricultural research. Costly laboratory trials could be done in public sector organizations, while field work could be implemented jointly, mostly through engaging temporary researchers on a result-oriented contract basis.

Proposals for Research

Assuming that an adequately performing research system can be put in place, an important field to undertake research in would be the screening of crops and crop varieties against soil salinity. There is an urgent need in the coastal region for crops that can have satisfactory yields in saline soils. This kind of research is not carried out at the moment, not in private, nor in public institutions. Another priority would be to generate more knowledge that can lead to specific soil management measures that improve the plant growth in saline conditions. In other words, to understand and address the capacity of salt to hold available moisture and not make it available for the plant. The topic would be the relation between physical properties of the soil related to soil moisture and its influence on soul-plant-water relations at various soil salinity levels.

Agricultural Extension

The Department of Agricultural Extension should make a serious effort to indeed implement its own extension policy. Experiences in the successive CDSP phases form a firm basis to do so. The concept of Production Development Zones should be a part of an adapted extension strategy. Also DAE should assess the experiences with the Farmer Field School approach in aquaculture and animal husbandry, and see whether elements of that methodology can be applied in crop production as well.

Livelihoods

The maximum ceiling of allotments of lands to landless households in newly accreted *khas* land areas stands at 1.5 acres. Given the relatively low cropping intensity and low productivity in coastal areas, especially the chars, households have to rely on other sources for their livelihood. Diversification of their income stream is a necessity. This book gives much attention to forestry, aquaculture and livestock. Any future livelihood oriented development program should take this reality into account and should follow an integrated multi-sectoral approach.

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Chapter 8

Land Settlement: The Process of Providing Land Titles

Dr. D.K. Chowdhury, Mohammad Abdul Latif and Rezaul Karim

8.1 INTRODUCTION

In a country as densely populated as Bangladesh, with between 900 and 1,100 people per square kilometer, it is no wonder that land is a central issue in any rural, or for that matter urban, development effort. Land is obviously scarce, but in the case of Bangladesh, not totally finite. As chapter 2 has shown, the country is extending southwards, due to a net accretion of land in the Bay of Bengal. This chapter explains the policies and rules that apply to the process of allocation of the newly emerged land. Most important in this respect is that policies are favoring landless families in the allocation of this new land. The complicating factors that can make this process cumbersome and time-consuming, will be highlighted. The chapter continues with the description of the innovative steps that have been taken in the subsequent phases of the Char Development and Settlement Project to streamline the procedures and to make the whole process more transparent. Towards the end, information is provided on the question of land retention: to what extent was the outcome of the allocation process sustainable?

8.2 THE POLICY AND LEGAL CONTEXT

8.2.1 Titles on Accreted Land

The land laws of Bangladesh references are made to the loss of land by flooding and to land accretion by alluvion. Gaining of land by alluvion is of two types: (a) reformation in situ (land formed on the same site of the old land, which was previously lost) and (b) land accreted and formed at a new site. In 1972 a law was enacted stipulating that all accreted land would be treated as Government (*khas*) land, even if the land was accreted in a place that was previously, before it disappeared, privately owned. However, in the cases of reformation in situ, the right of the previous tenants (landowners) has been restored in 1994, by adoption of the State Acquisition & Tenancy (Amendment) Act, 1994. This Act states that the right, title and interest of the previous owner will exist for a period of 30 years, subject to the general ceiling of owning 60 *bigha*s (19.8 acre) of agricultural land for a family. This means that a tenant will still have the right title and interest of the land reformed in situ provided the reformation occurs at the same site within a span of 30 years. However, the chars accreted in a new place, will continue to remain vested in the Government. Such land will be available to the Government for fresh settlement as per existing Government policy.

The Government conducts settlement of *khas* land in accordance with the Agricultural *Khas* Land Management and Settlement Policy of 1997. The policy states that *khas* land will be distributed to (a) households, which have no homestead and cultivable land, but depends on agriculture; or (b) agriculture dependent households having a homestead up to 10 decimals of land. Such landless households are entitled to a maximum of 1.5 acres of *khas* land in the coastal char areas and up to 1 acre in other areas, subject to the availability of such land. More than one member of a household is not entitled to *khas* land settlement. Agricultural *khas* land so settled is not transferable in any way other than by inheritance. In case of transfer of any settled land, the settler will lose his/her land title and the land in question will again be vested back in the Government as *khas* land.

As a consequence of the Act of 1994, not all the reformed chars (newly accreted land) can be treated to be *khas* land of the Government. Whenever and wherever land is accreted and chars appear, the Deputy Commissioner on behalf of the Government. has to take over the possession of the chars, conduct a survey of the area and prepare appropriate maps. The map should show the comparative configurations of the previous locations of the chars and the area where new chars were formed or reformed. If an area appears to be reformed in situ, the Deputy Commissioner will examine the records and documents submitted by the claimants, if any. He has to carry out a critical examination of the maps showing the chronological growth and location of the accreted areas through local investigations and collection of local information regarding chronological reformation of the new land. After careful examination of the maps and local evidence, if he is satisfied that the area is reformed in situ, i.e., it has appeared exactly in the same place and the claim has good and valid grounds for acceptance, the Deputy Commissioner will exclude the area from the *khas* land category. The title of the previous owner is retained and this area will not be considered as land available for settlement.

8.2.2 Various Claims and Complexities

Given the legal and policy context, a number of claims and complexities have occurred over the years, that compounded the actual practice of land settlement in the char areas. Government departments have made claims on newly emerged char lands and complex title disputes appear regularly while deciding the ownership of the accreted areas. In addition, new lands often give rise to disputes about the jurisdiction of the land.

Claims by the Forest Department

The Forest Department claims that the Land Administration and Land Reforms Division of the Government under Notification no. 344(4)-5-136/76. L.S. dated August 13, 1976 transferred a total area of 1,230,000 acres of newly accreted land falling within the jurisdiction of the coastal Districts of Chittagong, Noakhali, Barisal and Patuakhali to the then Ministry of Forest, Fisheries and Livestock for a period of 10 years for the purpose of coastal forestation. This was aimed at the conservation and stabilization of the accreted land in order to make the land suitable for cultivation. An area of 450,000 acres of land was located in Noakhali District, falling between 22°30′ to 21°30′ North Latitude, 91°00′ to 91°30′ East Longitude. However, in the Notification, a condition was clearly mentioned that after the tenure of 10 years these lands would be reverted to the Ministry of Land. Eventually, the area had not been physically transferred to the Forest Department on the basis of any formal survey. The area was mentioned in an official notification specifying certain latitudes and longitudes only. The physical location and actual status of the land was not unambiguously defined and identified. During this transfer order, it was not determined whether any part of the land is cultivable or used by households or for public purposes.

In 1984, the Ministry of Agriculture, Forest and Fisheries requested the Ministry of Land Reforms to extend the transfer period from 10 years to 20 years, on the ground that 10 years were not enough for the Forest Department for completion of plantation and for stabilization of newly formed land. However, no information was available as to whether the Ministry of Land and Land Reforms agreed with this request or not. No information is also available to show whether the conditions of the allotment had been complied with. It should be noted that according to existing laws newly accreted lands are brought under jurisdiction of the Forest Department to development of plantations for a stipulated period of 20 years.

Later on, the Ministry of Forest and Environment issued another Notification on 30th September, 1999 declaring the Government decision to constitute "Reserve Forest" over another area of 3,80,000 acres of accreted land situated within 22°55′ to 22°30′ North Latitude and 90°50′ to 91°30′ East Longitude in the District of Noakhali. These areas appeared to have been added to the area that had previously been declared to be 'reserved forest' under the notification of 1977. In that case, the total allocation of land for forest stands at 8,30,000 acres in the District of Noakhali only. However, this situation has not been spelled out in any statistical records of the Forest Department.

The Forest Department started implementation of the afforestation plan in the areas notified as "Reserve Forest" under a development project financed by the World Bank. The Department started afforestation in these new chars in 1986. About 33,512 hectares of land were brought under forest plantations under the World Bank project and other programs. While the accretion process had been increasing the level of the new lands, the people who lost their land in neighboring areas due to erosion, started to move towards these forest areas and began to cut the trees to make way for agricultural land. In order to incorporate one of these deforested areas in the CDSP project, the Government took the decision through an Inter-Ministerial meeting in 2001 to transfer Boyer Char to the District administration of Noakhali. Consequently, on the basis of the decision of that meeting, the District took over the possession of the lands as *khas* lands vested in the Government.

Claims Related to Shrimp Cultivation

After growing of shrimps in ponds had proven to be a commercial attractive enterprise, well connected shrimp cultivators started to put pressure on the Government to allocate more land for production ponds. Their first success was achieved in May 2003 when the Ministry of Land declared in a Government notification nearly 11,956 acres as "Chingri Mohal". The cultivators had second success, after submitting a proposal through one of the Ministers for allocation of *khas* land for shrimp culture. On the matter, an inter-ministerial meeting was held (February 2004) presided over by the Minister-in charge of coordination of development activities of Noakhali District that resulted in the following decision:

"The available *khas* land of Noakhali District will be used in the following proportions:

(a) One-third for the rehabilitation of the landless people as per existing Government policy; (b) one-third will be used for afforestation including social forestry and (c) one-third will be used for fish– and shrimp culture."

These decisions were profoundly contradicting the prevailing Government policy as declared under the Agricultural *Khas* Land Management and Settlement Policy of 1997, which provides that the agricultural *khas* lands can only be allotted to landless people of the area. This policy was passed by the Parliament and hence cannot be overruled by an inter-ministerial meeting. Since the policy of 1997 is not amended by the Government, there is no legal scope for the allocation of the *khas* land of the coastal areas for fish– and shrimp culture. The Forest Department never submitted a claim, based on the result of the inter-ministerial meeting. However, the Ministry of Land declared 9,796 acres of land involving some Upazilas of Noakhali District as shrimp land, in a Government notification of June 2004. This created an uncertain situation and a hostile atmosphere in the area. Landless people with claims on *khas* land were up against influential persons interested in shrimp culture. In some cases, landless households were forcefully evicted from the area. However, the High Court has declared the post of "Minister in-charge of coordination of

Districts development activities" and the actions taken by them in February 2004 as "void and illegal". As a result, the decisions of the inter-"ministerial meeting of February 2004 do not have any legal value for action. Consequently, the status of these accreted lands remains entirely as *khas* land and they are disposable by allotments to landless families.

As far as the notification of May 2003 is concerned, this decision strengthened the hand of the shrimp farmers. They indulged in evicting the settlers by force from their settled land causing various unwelcome results. Nijera Kori, a national NGO took the case to court and till the present the case is still pending before the High Court. One of the consequences is that the process of land settlement in the disputed area is severely hampered.

Ancestral Claims

As explained in 8.2, the State Acquisition and Tenancy (Amendment) Act of 1994 opened the way for ancestral claims for new in situ formed chars. This legal provision has been used in a just way by people with a valid presumption that their ancestral families held title on since then eroded land in the same location as the freshly emerged chars. The District administration can honor these claims after having done the required surveys. However, also land grabbers have used the same provision and have applied for a title on new lands, based on fake ancestral claims. They submit various documents in favor of their claims and the administrative authorities take a very long time to decide these title issues. In the meantime, the claimants create various encumbrances over the land so that the Government cannot proceed with the disposal of the *khas* land in terms of the law of the land. The claimants even enter into court litigations and cases so that matters linger even longer and rightful settlement is further postponed.

Ambiguous Situation with Regard to the Jurisdiction

The dynamic nature of the Meghna estuary, as depicted in Chapter 2, poses a problem for undertaking surveys. The Directorate General of Land Records and Surveys (DGLRS) is the authority for conducting surveys of all categories of land. This department cannot conduct surveys of the accreted areas properly till the chars are matured. As a result, an ambiguous situation prevails for a long period, because fixing up the extent of land could not be done adequately. Results of surveys done in the past are in many instances no longer valid because some of the chars are found to be completely disappeared, while others accreted substantially. Consequently, the extent of the areas of the surveyed *mouza*s (a unit of land administration which is drawn on revenue maps during the revenue survey by the Collector and cadastral survey by DGLRS; (*mouza*s are formed, maintained and used by the Collector and the Ministry of Land administration) changes after every survey. The Upazila land offices cannot update the status of the chars and islands because of a lack of sufficient technical manpower and, as a result, they cannot supply the exact data on areas of the *mouza*s as their nature and shape change very often due to dynamic changes by erosions and siltation in the coastal areas. As such, the maps and records of different surveys during different times give varied configuration and description of areas. Again, it has been found that during the process of surveys, many local areas have been changed abruptly before the completion of the survey process and the publication of the results. In such cases, new surveys are required.

As mentioned, the DGLRS is the authority to conduct surveys. It carries out "revisional" surveys for areas that were surveyed in the past and "cadastral" and "*diara*" surveys for new areas, including freshly accreted land. However, the District administration, on the basis of the Agricultural *Khas* Land Management and Settlement Policy of 1997, is entitled to conduct surveys and prepare "*charcha*" maps to identify *khas* land that can be distributed to landless households. These two different streams of surveys have created anomalies and overlap in the past. Coordination and harmonization is called for. The Zonal Settlement Officer, the official representative of DGLRS, can play a fruitful role in this respect as and when required by the Collector (Deputy Commissioner) at the district level.

One of the consequences of the survey problem is the fact that the jurisdiction over newly formed char areas is often a disputed issue. Different Districts, and even different Upazilas and Unions, claim that the same char is part of their jurisdiction. In practice, this has led to huge delays in the process of land settlement, because it was uncertain through which administrative channels the process had to proceed. In some cases, such boundary disputes have been resolved with the assistance of the Commissioner and of local Members of Parliament. Sometimes it led to litigation in court if other avenues failed to solve the matter. For instance, two writ cases in the High Court and one civil suit in the District Court came up over a dispute regarding the boundaries of Boyer Char between Noakhali and Lakhsmipur Districts. One administrative enquiry over the boundary disputes between Chittagong and Noakhali Districts on Urir Char is still continuing. Given the fact that the process of char formation will continue, it can be expected that such unfortunate situations will re-occur with some regularity. A proper mechanism with a fixed procedure to address such disputes could prevent many of the current uncertainties and is therefore justified.

Illegal Migration of Settlers to Newly Emerged Lands

When a new char becomes fit for cultivation, the river-eroded families from adjacent areas start migrating into the newly formed land for shelter and livelihood. The settlers are mostly from the other coastal chars and offshore islands who have lost their land due to erosion or due to the poverty trap that they found themselves in. In most cases, these settlers start moving on to a new char. A power broker, in many cases with ancestral links with newly accreted char land tends to extend support and patronage to settlers coming from the same area. This type of autonomous settlement leads to a situation in which the official process of land settlement cannot start with a clean slate. Settlers are already present in new chars with active control over land and staying physically by raising some huts and living with their family members before the official process has even started. Powerful people, commonly known as *jotdar*, and the settlers controlled by them occupy land. Often latecomers end up with tiny plots of homestead only. Informal transfer of money to powerbrokers to keep possession of the land is a common feature.

The illegal immigrants and occupiers of *khas* land ruthlessly begin with felling trees, constructing thatched houses on raised mounds and digging ponds for drinking water and a little fish culture. Due to the salinity of the soil and the recurrent floods, usually only one crop (aman) can be grown. The Forest Department is just not able to protect the plantations because it lacks the manpower and it faces influential opponents with political connections. Armed gangs (bahinis) are the local strong arm of the *jotdar*s. They often impose a regime of fear and terror on the settlers, violating basic human rights. They extract large amounts of money from the settlers in exchange for the control over and use of a piece of land and for "protection". In the process huge forested areas have been denuded and many Forest Department officials had to leave the occupied areas.

This is the situation that development projects like CDSP and others are facing when taking up activities in newly accreted areas. The land is occupied by settlers oppressed by powerful people, living in an unprotected area that is subject to regular flooding, with no drinking water in winter and no system of communication. For food they are dependent on a low-yielding rice *aman* crop, some *rabi* crop and little fish grown in ponds or caught in open waters. As said, the land settlement process can not start with a clean slate. In a strange way however, the involvement of the *jotdar*s and their bahinis can be considered to be the pre-cursors of this official settlement. They know the land laws and, on the whole, do not give settlers more land than 1.5 acre per household.

8.3 THE PROCESS OF LAND SETTLEMENT

8.3.1 Government Procedure for Settlement of Char Land

As mentioned earlier, the Agricultural *Khas* Land Management and Settlement Policy of 1997 sets the objectives of land settlement and clearly indicates that landless households are the beneficiaries of newly emerged lands, if no ancestral and other rightful claims exist. It also sets the stages and procedures of land settlement. The precise rules of settlement are stipulated in the State Acquisition and Tenancy Act of 1950. The two combined lead to the following procedure for the whole process, from identification of *khas* lands to the distribution of land titles.

Selection of Khas Lands for Settlement

1. The Upazila (sub-District) Agricultural *Khas* Land Management and Settlement Committee, having 12 members, prepares a preliminary list of the available agricultural *khas* land, publishes it widely and invites objections against the list, if any, from the members of the public of the areas concerned.
2. Objections to this preliminary list have to be submitted within 30 days of publication of such notice and the Upazila Committee gives its decision within 15 days, and then publishes the final list.
3. Appeals if any, against the decisions of the Upazila Committee are submitted to the District Agricultural *Khas* Land Management and Settlement Committee comprising of the Deputy Commissioner as the Chairman and 10 others as members. The Member of Parliament of the concerned Upazila acts as its Advisor. This District Committee gives its decision within 15 days.
4. Within 30 days, appeals against the decisions of the District Committee may be submitted to the National Agricultural *Khas* Land Management Executive Committee comprising of 24 members under the chairmanship of the Land Minister. This Committee gives its decisions within 60 days, and then the final list of the *khas* lands is published.

Selection of Landless Households for Settlement of Khas Lands

1. Applications from landless people are invited by the AC (Land) of the Upazila to be submitted within one month.
2. Within one month the Upazila Committee finalizes the scrutiny of the applications and prepares the list of selected candidates for settlement of *khas* land.
3. The Assistant Commissioner (Land) (AC Land), who is also member-secretary of the Upazila Committee, produces the list of the applicants before the Upazila Committee. The Committee in its meeting selects the applicants and forwards the selected list to the Deputy Commissioner for approval of the District Committee.
4. On the basis of the selected list, the AC (Land) prepares settlement cases (*jamabandi*) for each selected family and sends the cases to the Upazila Nirbahi Officer for endorsement and onward transmission within 21 days to the Deputy Commissioner.
5. Within 30 days, the Deputy Commissioner refers the cases to the District Committee and the District Committee scrutinizes and approves the Upazila list.

6. After approval by the District Committee, the Deputy Commissioner gives his approval to each settlement case and sends these cases back to the AC Land.
7. "*Salami*" (token price at one Taka per acre of land) is officially received from the selected landless family against each case and the *kabuliyat* (deed of agreement) for each case is executed by the landless family at the Union Land office.
8. Executed *kabuliyat*s are approved and signed by the AC (Land).
9. *Kabuliyat*s are then registered by the Upazila Sub-Registrar.

x. *Khatian*s (records of right) are prepared by THE AC (Land) withIN 15 days.

xi. *Jodh*s (records of mutational *khatian*) are opened withIN 21 days.

xii. FINally, THE *khatian* and THE actual possession of THE land is handed over to THE landless family withIN 15 days.

8.3.2 Innovative Steps of CDSP in Land Settlement Process

In CDSP, the land settlement process generally follows the Government's Agricultural *Khas* Land Management and Settlement Policy of 1997 and the procedures laid down in the State Acquisition and Tenancy Act of 1950, as summarized above. However, certain adjustments have been made by CDSP in order to make the process more efficient and transparent, and to bring it closer to the settlers. These adaptations have in principle reduced the cumbersome and lengthy land settlement process to the following eight stages:

a. Information about the upcoming *khas* land settlement is disclosed in the locality through public notice and local meetings.

b. Under the general supervision of the Deputy Commissioner, the "plot-to-plot" survey of the new chars is carried out (see below).

c. Objections to the "plot-to-plot" survey are received through public notice.

d. The Upazila Committee holds public hearings in the field for disposal of the objections, if any, and selection of landless households. Settlers are assisted in filling up the official forms quickly and correctly.

e. The AC (Land) officially initiates the settlement cases (*jamabandi*) for each family, gets approval from the Upazila Committee and forwards these to the District Committee for necessary approval.

f. District Committee approves the list and the Deputy Commissioner approves the *jamabandi* cases and sends these cases back to the AC (Land).

g. After approval by the District Committee, the AC (Land) executes khabuliyats (deed of agreement) with the settlers and gets the khabuliyats registered by the registering authority in the field.

*Khatian*s (records of right) are prepared and handed over to the settlers, along with registered khabuliyats and physical possession of the land is delivered, where necessary.

This streamlined process simplifies and expedites the Government's usual procedures for *khas* land settlement. The greater transparency and the fact that much of the process is brought to the people's doorstep created a feeling of safety and confidence among the landless community. A few of the innovations in the methodology as adapted in CDSP are elaborated upon below.

Information Dissemination about Land Settlement Procedures: In the beginning of the CDSP-I project it became clear that the char settlers were not well informed about the steps and stages of *khas* land settlement procedures. as a result, many genuine landless families could not even submit applications for allotment of *khas* land, while *jotdar*s would attempt to grab land allotments by showing some fake people as landless. Based on these experience, a system of dissemination meetings was introduced. a series of area-wise meetings were held separately for men and for women. During the meetings the settlement rules and procedures and the time frame for applications were explained to the char population.

After the plot-to-plot survey, the results were also disseminated through mass meetings and through newly established local field level institutions namely the Local Area Development Committees and the (Sub) Polder Committees under CDSP.

After the establishment of more permanent institutions as Water Management Organizations, these were used as channels to refresh the knowledge of the settlers about the procedures.

Support from Field Level Institutions for the Settlement Process: Field level institutions, such as Water Management Organizations (WMO) and NGO groups in CDSP areas, play an effective role in dissemination of the procedure of the land settlement process as stipulated in the Government policy. They are also involved at the time of the public hearings in the field. The Chairman and members of the Union Parishad who are also representatives of the field level institutions give evidence related to the queries of the Upazila Committee. The support and evidence from the side of the local level institutions are important factors in the selection of the genuine landless households.

Plot-to-Plot Survey (PTPS): The identification and determination of *khas* land available in new char areas is a problematic issue facing the Ministry of Land officials at District– and Upazila level. Usually, information of *khas* land is collected from Register VIII (part 2) which is kept in the offices of the AC (Land) and in the Union Land Office. However, this Register is often not maintained regularly as the survey of the char area is not conducted by the DGLRS or the Deputy Commissioner's office immediately after formation of the chars. In addition, manipulation of information and dishonest practices are widespread in the records of the char areas. Even, if the Register contains the correct information, it does not say everything about the actual occupation and possession of the land. In CDSP-I, the plot-to-plot survey was introduced. Its main objective was to determine the configuration, classification and extent of the land, its title status and identity of the occupiers. It is essentially a census survey, investigating the status of each plot of land providing the most up-to-date information. as described above, the output of the PTPS is a *mouza* sheet map, with details of the occupiers with extent and classification of the land.

The PTPS covers the entire new char area and all the settlers in that area. The work is carried out on the basis of a *diara* survey map or a map prepared by way of a cadastral survey. The *diara* maps, however, do not reflect the exact location of a particular piece of land. In many cases, the char lands are changed substantially (by erosion and/or additional accretion) after finalization of the *diara* maps. The PTPS provides an updated map of the area, giving the exact position of each piece of land.

The experience in CDSP shows that the PTPS forms the backbone of the land settlement operation. It has been proven to be a reliable database that has a great impact upon the quality of land settlement. It significantly reduces land disputes and subsequent litigations. as the PTPS results are published and widely disseminated in the area, it contributes to the transparency and fairness of the land settlement process. It creates hope and aspiration among the landless to obtain the title on the land.

Publication of Results and Hearings of Objections, in the Field: After consolidation of the PTPS data, the information is published in all localities for public inspection. The publication is done by attaching the list of results at convenient places in the local areas. The population is invited to review the list and to file objections if they find any incorrect entry about land or its occupants. This publication is done by the AC (Land) of the Upazila under the provision in the Agricultural *Khas* Land Management & Settlement Policy of 1997.

As stated above, the publication of the PTPS results makes the settlement process transparent. It boosts up the confidence among the landless in the settlement operation.

All objections have to be filed within 30 days after publication. The Upazila Agriculture Land Management and Settlement Committee then meet in the field (and not in the office of the UNO or AC (Land) for hearings and for finalizing the *khas* land list. These hearing sessions take place in the field at *mouza* level, openly and in presence of the people of the locality.

Disputes Identified during Hearings at Field Level, Solved in the Same Session: The decisions on the disputes during hearings at field level are declared on the same day during the same session as the hearing. However, if necessary, the surveyors of AC (Land) office are sent for investigation and physical verification in respect of the disputed land.

Selection of Landless Households done in the Field: The selection of landless families is a critical process and a vital stage in the settlement process. During open hearing sessions the selection of landless households is done by the Upazila Committee, often in presence of representatives of field level institutions, after taking into account testimony of the members of the public.

Priority for Women Headed Households: In the process of selection of landless households, wherever possible, priority is given to women headed families including widows, women deserted by husbands, widows deserted by children, etc. These households are in a disadvantageous position in the society because of the absence of a husband, which even further diminished their economic opportunities and social status.

Woman's Name is Written First in the *Khatians*: Names of both husband and wife are written in the *khatian* as owners with a share of 50% each. At the proposal of CDSP, the Secretary Ministry of Land gave a local declaration in May, 2007 for writing the woman's name at the first place in the *khatian*s of CDSP III. The practice strengthens the bargaining position of the woman when dealing with the management of the land and even while mortgaging the land. This process has created a great sense of ownership of the land among women. The male member now cannot take any decision regarding management of the land singularly. This decision will further stimulate the empowerment of women settlers, strengthen the conjugal ties and ensure retention of their land. This unique system was introduced in CDSP-III and is regarded as an example to be introduced throughout the country.

Signing and Registration of *Kabuliyat* and Handing over of *Khatian* are done in the Field: The Kabuliats (i.e., the deed of agreement signed by the Assistant Commissioner (Land)/Upazila Nirbahi Officer on behalf of the Government as first party and the landless allottee as second party) is a very important legal document as it proves the transfer land by the government to the landless family and hence requires to be legally registered through the Sub-Registrar of the concerned Upazila. The registration works are generally done at the Registration offices, which are usually located at the Upazila headquarters, which are generally located at a distant place from the remote coastal chars. However, if anybody wants to have the documents registered at any other place, on the plea of old age, ailment, disability, etc., an additional Government fee of Tk. 450 per document applies on top of the normal registration fees. On approaches by CDSP and on the recommendation of the Ministry of Land, the Ministry of Law issued an official instruction to the Sub-Registrar of Hatiya Upazila to hold "field registration camps" at Boyer Char for registration of the *kabuliyat*s at least once a month. It is the first time in the country that such field camps are held. This has saved the people of Boyer Char from crossing the Hatiya river and going up to the distantly located Hatiya Upazila Head-quarters to appear before the Sub Registrar. And settlers not have to pay the extra fee of Tk. 450 as the Registration Camp assumes the status of a regular government office. This system has been maintained in all the subsequent phases of CDSP and may be replicated by the concerned Ministries in all the areas concerning settlement of newly accreted land.

Project Approach in Settlement Operations: Experience in CDSP has led to the conclusion that it is very important to follow a project approach for each settlement operation. a work plan should be made before the operation starts. This work plan should include assessment of the total workload, the staff required for the settlement process, all costs involved and a time schedule. The plot-to-plot survey adds to the usual costs of a settlement operation. The survey provides however clear and up-to-date information which very well might save costs and time during other stages in the process. For the planned land settlement activities in Char Nangulia, Noler Char and Caring Char (under the fourth phase of CDSP), the Ministry of Land has included the costs of the plot-to-plot survey in its own budget. This practice may be replicated by the Government in other settlement operations as well.

8.4 DISTRIBUTION OF LAND AND LAND RETENTION IN CDSP AREAS

8.4.1 Land Distributed Under CDSP

As is depicted in table 8.1 a total of over 34,000 land titles have been issued in a period of about 20 years (from 1997 when settlement activities started to 2018) in the framework of CDSP. The simplified methodology as sketched in the previous paragraph was followed. Though this procedure was more efficient, still it took on average at least 10 months to complete it, from opening a settlement case till handing over of the *khatian*. Some cases, however, with complicated backgrounds and histories, with claims and counter claims, took years to reach a successful end.

Table 8.1 Status of *Khas* Land Settlement Under CDSP-I, II, III & IV

Project Phases	Land Settlement (Area in acres)	Land Title distribution (Households)
CDSP-I (1994-2000)	5,842.00	4,494 (Target-5,000)
CDSP-II (2000-2005)	10,188.00	7,837 (Target-8,000)
CDSP-III (2005-2011)	10,820.00	8,323 (Target-10,000)
CDSP-IV (2011-2018)	17,560.00	13,508 (Target-14,000)
Total	**44,410.00**	**34,162**

8.4.2 Land Retention

The 34,000 households that received a title on land in the context of the phases of CDSP, where allotted in total 44,000 acres. This means that the average size of land obtained by one household was around 1.3 acre. The intriguing question is, whether settlers were able to hang on to their piece of land or whether they had to "sell" it (which is legally not possible as we have seen) In order to get some answers on this question, during CDSP IV outcome monitoring via Annual Outcome Surveys (AOS) has been being conducted since 2012. During CDSP IV, six rounds of AOSs data were collected from three panel samples each of 200 households in the following domains: (i) CDSP I-II, (ii) CDSP III; and (iii) CDSP IV. The first round of AOS was conducted in 2012 and repeated annually till 2019.

The surveys showed that a total of 102 households were displaced of which 19 (3.2%) by own family decision and 83 (13.8%) by river erosion. For more details please see the table below.

Table 8.2 Displacement of Households Monitored during CDSP IV

Phase	Samples in AOS	AOS Year	Migrated/Displaced		Total Displaced	% over Phase		% Total Displaced	Name of Coastal Chars/ Unions/*Mouza*
			Family decision	River erosion		Family decision	River erosion		
CDSP-I	120	2015	1	0	1	0.8	0	0.8	Char Kolmi (CBT)-1
		2019	3	0	3	2.5	0	2.5	Nabagram (CBT)-2, Char Jabbar (CBD)-1
CDSP-II	80	2015	2	0	2	2.5	0	2.5	Char Mohiuddin (Moradona)-1, Char Boishaki-1
		2019	1	0	1	1.3	0	1.3	Char Boishaki (CBT)-1
CDSP-III	200	2015	8	0	8	4.0	0	4.0	Boerchar-8
		2019	0	10	10	0.0	5	5.0	Chatla Khali (Boyer Char)-10
CDSP-IV	200	2015	2	13	15	1.0	6.5	7.5	Urir Char-1,Noler Char-1,Char Nangulia-1,Caring Char-12
		2017	0	30	30	0.0	15	15.0	Char nangulia-2, Noler char-3, Caring Char -25
		2019	2	30	32	1.0	15	16.0	Urir char-1, Char Ziaudding-1, Char Nangulia-17, Noler char-5 and Caring-8
Total	**600**		**19**	**83**	**102**	**3.2**	**13.8**	**17.0**	

Note: AOS: Annual Outcome Survey.

Sources: The Panel Surveys (Annual Outcome Surveys 2012 to 2019).

Much earlier, in the year 2000, CDSP started to follow a cohort of 453 *khatian* holders from CDSP I polders (Char Majid, Char Bhatir Tek and Char Baggar Dona II), out of a total of 4,494. Through annual surveys a number of variables were monitored, among them the actual land holding. In 2006, a sample of 78 households from Char Mora Dona (a CDSP II area) was added, out of a total of 1,067 *khatian* holders in that char. The data in the tables below are derived from these surveys.

Analyzing the samples, it turned out that 6.1% of the households that received a *khatian* were not living inside the area concerned (see Table 8.3). They were non-local settlers that actually should not have received any land but somehow slipped through the procedural net. The non-locals got a similar percentage of the distributed land (table 8.4).

Table 8.3 Percentage Distribution of Households by Location Status in Four Areas

Settler Types	Polders								Total	
	CM		CBD-II		CBT		MD			
	No.	%	No.	%	No.	%	No.	%	No.	%
Local settlers	107	96.4	83	100	228	90.5	62	95.4	480	94.0
Non-local settlers	4	3.6			24	9.6	3	4.6	31	6.1
Total	**111**	**100**	**83**	**100**	**252**	**100**	**65**	**100**	**511**	**100**

Notes: CM=Char Majid CBD II=Char Baggar Dona II CBT=Char Bhatir Tek MD=Char Mora Dona.

Table 8.4 Percentage Distribution of Land by Location of the Settlers

Settler types by location	Percentage				Total
	CM	CBD-II	CBT	MD	
Local settlers	95.9	100	91.9	91.9	93.8
Non-local settlers	4.1		8.2	8.1	6.1
Total	**100**	**100**	**100**	**100**	**100**

Table 8.4 shows that the total average land allotment was 1.26 acres for the three polders and Mora Dona together. About the same average size as for all households that received land. However, all settlers did not get possession of all their allotted land because they were denied the possession by the previous occupiers, in most cases *jotdar*s with fake claims. The table indicates that overall 94.5% of the land for which a title was received, were actually handed over to the legal owners.

Table 8.5 Average Allotted and Possessed Land by Local Settlers

Polders/area	N=	Average Land (acres)		% possessed
		Allotted	Possessed	
CM	107	1.03	0.98	94.6
CBD-II	83	1.31	1.25	95.5
CBT	228	1.52	1.42	93.7
MD	62	0.61	0.60	98.8
Overall	**480**	**1.26**	**1.19**	**94.5**

The number of households that received a land title and left the polder since then has been very low during the first about six years after settlement. Since then, the outmigration increased, largely due to the fact that newer chars (as Char Nangulia, Noler Char and Caring Char) with opportunities for more land attracted settlers from CDSP I and II areas. Over the last three years, the relative number of households that moved out grew from around 8% to 21%. Most sold their land (12% of total land was involved), which means illegally transferred their land to others, some of them still possess land in the location they migrated from. Table 8.6 provides details per area.

Table 8.6 Distribution of Local Settlers by Present Location Status

	Areas								Total	
	CM		CBD-II		CBT		MD			
	No.	%	No.	%	No.	%	No.	%	No.	%
Living inside	74	69.2	74	89.2	183	80.3	48	77.4	379	79.0
Left polder but hold land	6	5.6	3	3.6	10	4.4	2	3.2	21	4.4
Left polder selling land	27	25.2	6	7.2	34	14.9	12	19.4	79	16.5
Others*	0	0.0	0	0.0	1	0.4	0	0.0	1	0.2
Total	**107**	**100**	**83**	**100**	**228**	**100**	**62**	**100**	**480**	**100**

Note: Left polder, failed to get possession.

Table 8.7 gives the retention of land of the settlers in the sample that stayed. They kept approximately 85% of their allotted and possessed land. In other words, they have lost 15% of their possessed land after they have received the official land title of their land/allocation of land from CDSP. A considerable part of the lost land undoubtedly will have been distress sale, due to need for cash to cope with food shortages and other necessary expenditures. The remarkable increase in land prices with nearly 300% in the period 1998 to 2008, made selling an attractive option, though it went against the conditions of the title deed. Some of the sales were to *jotdar*s who kept their influence in the area. The percentage of lost land stayed about the same over the last three years, but was much lower in the initial period after settlement.

Table 8.7 Land Retention Status of the Settlers Still Living in the Locality

Areas	No. of HH	Average land (acres)			% of land retention and lost/sold	
		Possessed land	Retained land	Sold land	Retained	Lost/sold
CM	74	1.05	0.89	0.16	84.4	15.6
CBD-II	74	1.34	1.13	0.21	84.1	15.9
CBT	183	1.49	1.22	0.27	82.1	17.9
MD	48	0.59	0.55	0.03	94.2	5.8
Overall	**379**	**1.26**	**1.05**	**0.21**	**84.6**	**16.4**

Households that are still living in the same place as at the time they received a *khatian* did however not only sell land, they also purchased new land. In table 8.8 it can be seen that they increased their original allotted and possessed average land holding of 1.26 acres to 1.44 acres. They retained 1.05 acres and added 0.39 acres though purchase (0.34) and inheritance (0.05). The purchased land is located both inside and outside the polder, but not in the new chars that are still controlled by *jotdar*s and their *bahini*s.

Table 8.8 Present Land Holding Status of the Settlers Still Living in the Locality

Areas	No. of HH	Possessed land (acre)	Present land holding by sources (acres)			
			Retained	Purchased	Inherited	Total
CM	74	1.05	0.89	0.48	0.04	1.41
CBD-II	74	1.34	1.13	0.17	0.01	1.31
CBT	183	1.49	1.22	0.40	0.07	1.70
MD	48	0.59	0.55	0.12	0.07	0.74
Total	**379**	**1.26**	**1.05**	**0.34**	**0.05**	**1.44**

Settlers still living in the same locality did enter into a relation with these *jotdar*s by acquiring illegal occupation of pieces of land in the most recently emerged and populated. chars. This increased the land they actually control from 1.44 acres to 1.68 acres, as is depicted in table 8.9.

Table 8.9 Khas Land in New Chars Occupied by Settlers Located in CDSP I Areas

	Number of HH	Initial land possession	Total legal land	Occupied *khas* land	Total
CM	74	1.05	1.41	0.54	1.95
CBD-II	74	1.34	1.31	0.04	1.35
CBT	183	1.49	1.70	0.17	1.87
MD	48	0.59	0.74	0.33	1.07
Total	**379**	**1.26**	**1.44**	**0.24**	**1.68**

The information provided in this section leads to the inevitable conclusion that many illegal transactions are occurring in transfers of land. Settlers are not allowed to sell land received under the *khas* land policy of 1997, still such illegal transactions happen with some frequency. As per terms of Kabuliats, if any such sale/transfer is made, the allotment will be cancelled and such land will be forfeited to the government as *khas* land and will be available to settle other suitable landless families. A number of them occupy *khas* land in newer, still not officially settled chars. This is against the law as well. However, the Upazila offices have not designed any system to review and monitor the retention of land. These facts should be taken into account in any new settlement operation in the chars. A proper land management information system would greatly facilitate any actions against illegal activities.

8.5 MODERNIZATION OF LAND RECORDS MANAGEMENT SYSTEM (LRMS)

In Bangladesh the land records are manually maintained by the land offices at the Union, Upazila and District levels. Various attempts have been made by the Government for modernization of the system of land survey and preparation of *mouza* maps by the Directorate General of Land Records and Surveys and management of the land records of District– and Upazila administration. But there is still no methodology that can be introduced on a country-wide basis. However, as a part CDSP's activities, software was developed to modernize the land record management system. This system has been applied and tested for management of the *khas* land settled under CDSP-II, III and IV areas.

This Land Record Management System gradually developed and modernized further. The system has the provision to keep records of all the government and non-government land data relating to the project, all records of mutation, maintenance of registers especially for settlement activities used in the Upazila and Union Land Offices, production and publication of settlement *khatian*s and day to day subsequent corrections of the land records. Presently, an on-line based system is in use in Upazilas in the project area such as Hatiya and Subarnachar in respect of the *khas* lands settlement under CDSP. A server computer with required IP Address was installed and is functioning in the Project Director's office (Deputy Commissioner's office) of the Ministry of Land, Noakhali. To run this online based software smoothly, broadband internet connections of the Deputy Commissionner's office was used. Upgrading and modernization of the LRMS software was completed during the CDSP-IV period.

It is the intention that the on-line based land record management system which was used under CDSP-IV, will continue in any subsequent phases in a more updated and developed manner, including a Geographic Information System (GIS). The present LRMS software does not support locational data based on a GIS. The plot to plot survey (PTPS) maps and individual plots data are not GIS based. Geo-referencing is essential to clearly define the specific position of a land plot and to locate the plots of an individual. So, to incorporate geographic data into LRMS software and to develop it as a mapping software, the LRMS system would be upgraded by developing a GIS database module. This will be an elaborate job as the existing maps will have to be digitized and correctly geo-referenced with reference to the neighbouring sheet maps. New surveys will be needed to use GPS equipment linked to the licenced GIS mapping software.

Based on the result of CDSP, the Government has initiated a pilot activity to bring two Upazilas, namely Companiganj Upazila of Noakhali District and Ramgati of Lakhsmipur District, into this computerized system. This activity was planned by the Government to assess whether the capacity of the system is indeed suitable to incorporate all land records of an Upazila and to update and issue the records.

The Ministry of Land is in the process of developing a system of E-Governance in the Ministry, the attached Departments and the Land offices of District and Upazilas. This will be carried out in several sub-projects under "Project on land survey, records preparation and preservation under digital process". This project has the following objectives: (a) to develop a customized application of software for imaging, archiving, retrieving and printing of *khatian* and *mouza* maps; (b) to use the customized software, computerization of all CS (Cadastral Survey), SA (State Acquisition) and RS (Revision Survey) *khatian* records and respective CS & RS *mouza* maps for all Upazilas; (c) to renovate the work place and supply of equipment, i.e., computers and allied accessories for easy and efficient imaging, archiving, retrieving and printing of land records; (d) to train relevant personnel. The first phase will consist of two sub-projects: "Computerization of existing *mouza* maps" (2012-2020) and "Project on establishment of digital land management process in three City Corporations, one Municipality and two rural Upazilas" (2018-2021).

Besides these ongoing projects the Ministry of Land has prepared a huge and ambitious project named "Land Management Automation Project" to transform the whole manual land management process into a digital process in the next five years. This project, with a project period from 2020 to 2025 is submitted to the Planning Commission for approval. The Ministry of Land will implement the project fully with Government funds. CDSP will continue with its LRMS program with GIS based improvements in its planned next phase.

8.6 SUGGESTIONS FOR FUTURE SETTLEMENT OPERATIONS

Reinforcement of the Official Structures for Coastal Areas

As we have seen, the dynamic nature of the Meghna estuary, the vast char areas that are emerging and the sheer number of households that are expected to be settled have revealed the shortcomings in capacity of the offices at District– and Upazila level that deal with land settlement and land management affairs. This situation gives rise to serious considerations for reinforcement of the capacity of these land offices in coastal areas. Presently, the government has been maintaining a uniform quantum of manpower strength in all the districts concerning the static plain land, hilly land and the coastal lands of the country. A special staff strength for coastal Districts and Upazilas should be introduced by the Government so that these offices may keep an effective control over areas having substantial accretion. Relocation from other offices is an obvious solution that would not require any increase in the personnel budget.

Land Use Plan

In order to identify the land available for allocation to landless families, an inventory of land has to be made which will be required for public investments as embankments, roads, cyclone shelters, ponds, educational institutions, fore-shore plantation, etc. Such a land use plan can only be made with full cooperation of and proper coordination with other Government agencies. Especially, BWDB, LGED and DAE play an important role in this respect.

Changes in the Land Settlement Procedures

The Ministry of Land should consider introducing the CDSP methodology in respect of the land settlement activities in all land settlement programs of the Government throughout the country. This would need a revision of the standard procedures that are presently in force. It would also need an increase in the concerned budget line, since a plot-to-plot survey may bring some extra costs to the settlement operation.

Coordination in Preparation of Maps

Improved coordination and harmonization of map making activities of DGLRS on the one hand and the District administration on the other hand will avoid any misunderstandings and repeat of work that was already done. The Zonal Settlement Officer could play a useful role in achieving this objective.

Application of Procedures in Future Programs

The monitoring of land retention through a cohort of settlers in CDSP I and II areas have brought to light that settlers have left the locality where they received an official land title and moved to newer chars, selling their land, contrary to the *khas* land laws. Other households stayed back and acquired control over land in new chars by making payments to *jotdar*s. Such developments can be corrected by a strict application of selection rules in the new chars in the next phases of CDSP. Households that received a *khatian* in earlier years, can of course not make a claim on a title on land again in new chars. Settlers that sold their land illegally should be held accountable.

Mechanism to Solve Boundary Problems

The District and Upazila administrative boundaries are not physically displayed and openly identified in the newly accreted char areas. This creates a complicated situation in many cases, leading to several court cases, fake claims and unrest among people in the chars in the past. It severely delays and obstructs the settlement process in the disputed areas. Because similar disputes are likely to occur in future chars as well, the Government should establish a proper and transparent procedure to address these disputes regarding administrative boundaries. After resolving these issues, permanent boundary pillars have to be placed at the demarcated areas, especially in the newly accreted areas.

Modernization of Land Records Management System

Bangladesh should rapidly move towards a computerized land records system to increase efficiency, reliability and transparency of the currently used manual methodology. It is admittedly a huge task. But with serious intentions from the side of the Government, including sufficiently large budgetary provisions, and with well coordinated international assistance, such a national system is not unfeasible. The "Project on land survey, records preparation and preservation under digital process" and even more so the "Land Management Automation Project" are encouraging signs that the Government has indeed attached a high priority to this crucial aspect of improving land management. The software developed under CDSP and the lessons learnt are valuable inputs in this process.

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Chapter 9

Changing Livelihoods: Institutional and Socio-Economic Transformation in Coastal Chars

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9.1 INTRODUCTION

This chapter describes the impact of the interventions of the various development programs on the daily lives of the families that have settled in the chars in the Meghna estuary. It does so by looking first to the patterns of migration into the chars (section 9.2) and the early social networks (section 9.3). The chapter then shifts to aspects of governance: field level institutions instigated from outside through projects (section 9.4), the emergence of government institutions (section 9.5) and the relations between all of these institutions (section 9.6). The combined impact of interventions and the new governance environment in social and economic sense is dealt with in section 9.7 The chapter concludes with a number of considerations for future char development programs based on the experience gained during the last 25 years from CDSP-1 to IV phases and other programs.

9.2 THE HETEROGENEOUS CHARACTER OF THE GROUP OF EARLY SETTLERS

As was described in the previous chapter, in particular section 8.2, a stream of migrants to new chars starts when the chars are stable and elevated enough to live on, while in most cases they are still under control of the Forest Department. This migration occurs due to various reasons. The main reason is that people lost their land and homesteads because of erosion. This is probably the case for 80 to 90% of the households that moved to new chars. This percentage varies for different chars. In Boyer Char, Char Nangulia, Noler Char and Caring Char practically all settlers are erosion victims. For the older chars as Char Majid, Char Baggardona and Char Bhatir Tek other factors played a role as well. Land was grabbed or was voluntarily sold. Grown-up siblings wanted land of their own and moved to new chars. People moved because they were victims of coercion and threats in their area. Some families were accompanying their neighbors who decided to migrate. Others were attracted by the possibility that in the new chars, government-led development plans will be executed. Of course, extreme poverty is a more general reason that lead people to search for opportunities elsewhere.

Families that moved to chars, come from far away and nearby places, but basically all migrated within the greater Noakhali area (Lakshmipur, Noakhali and Ferni districts). For example; the settlers to the Boyer Char, Noler Char, Caring Char, Char Nangulia and Ziar Char of Noakhali came from Hatiya, Ramgoti, Sandwip (in Chittagomg District), Shajbajpur, and Noakhali mainland. In Urir Char they have migrated from Sandwip island and Noakhali Companiganj area. Percentages of settlers composition and distance between the original homestead and the place of migration for a few areas are shown below. The figures mentioned show slight variations in different documents. The data in Table 9.1 are estimates based on the available data and practical experience. The high percentage of migrant's rate from Hatiya is striking. The fact that the northern part of Hatiya suffers from serious erosion because it is hit by the full force of the Meghna, plays a role. In addition, the people from the island feel comfortable that the area where they migrated to, still belongs to Hatiya administratively (Boyer Char, Noler Char, Caring Char and a part of Char Nangulia are a part of Hatiya Upazila).

Table 9.1 Origin of Settlers and Approximate Distance of Migration

Name of place migrated from	% of settlers migrated to five chars (estimates)					Longest distance from the ancestral place (km)
	Boyer	Mora Dona	Nangulia	Noler	Caring	
Hatiya	50-54	55	40-45	50-53	80-85	40- 45
Ramgati	28-30	15	15-20	20-22	03-04	20-30
Sandwip	03-05	-	05-07	12-15	05-06	50-60
Shahbajpur	10-11	08	10-15	10-12	05-06	45-50
Noakhali Mainland	06-07	22	15-20	05-06	05-06	02-05
Other places	01-03	01-03	01-05	03-05	02-03	

It is interesting to note that migration takes place over an extended period of time, growing over the years till the area of destination is no longer attractive because of overcrowding (see Table 9.2).

A migrant family usually tries to find a place close to others they already know for help and cooperation and as a means to maintain their identity and culture. This is a kind of preferential settlement based on kinship and local ties. This pattern favors sprouting of primordial groupings among settler groups from different origin rendering the char a gathering of many factions living side by side. So, at the early stage of migration, the composition is a heterogeneous mixture of groupings that lacks cohesion beyond their circles of belonging.

Table 9.2 Periods of Migration

Name of Area	% of migration in different period				
	70-79	80-89	90-95	95-2000	After 2000
Moradona	6.45	25.00	30.65	37.90	
Boyer Char	0.00	0.00	26.00	74.00	
Char Ziauddin	96.04	1.98	1.98	0.00	
Char Nangulia	0.00	0.00	0.00	60.00	40.00
Noler Char	0.00	0.00	0.00	60.00	40.00
Caring Char	0.00	0.00	0.00	40.00	60.00
Urir Char	50.00	30.00	05.00	15.00	

The interest of the household itself and of the faction it belongs to dominate the early relations in the char after settlement. Communications between the groups in this stage of settlement are limited, superficial and predominantly indirect in nature. The prevailing situation can be characterized as an environment of mistrust, silent animosity and lack of tolerance. The competition for access to scarce natural resources is the overarching issue.

9.3 THE EARLY SOCIAL NETWORKS

As sketched in the previous paragraph, many settlers want to stay close to families that they know from the place where they used to live. These groups or factions are thus the first networks that they are connected to. Participation in larger and more diverse social networks will increase over time. The tea stall in many cases provides the first stepping stone to this process of widening the pattern of relations. As soon as the first migration takes place, tea shops emerge, which constitute informal meeting places for people, especially for men. It might be odd to consider a tea stall an institution, however, they become platforms for information dissemination, networking and communication. Any piece of information, relevant or gossip, important or unimportant, discussed in tea stalls will find its way quickly to many households in the chars.

The more or less formal beginning of “clustering” of people is in many instances marked by the formation of a samaj. A samaj consists of a small number of families that live in close association and that has identified themselves as being a separate social unit within the bigger community. The driving forces that hastens the constitution of a samaj is protection, safety, achieving common interests as a unit and above all establish or reinforce an own identity. They are autonomous groups, with no connection to higher religious or secular authority. An important functions is to serve as a vehicle for conflict resolution. Each samaj gives a name to itself, in many cases prefixing or suffixing something from the ancestral place. Senior male persons give leadership to the samaj and represent their unit in formal gatherings like indigenous judicial meetings (*shalish*), meetings on land settlement and on formulation of needs. In Boyer Char, with a population of around 9,000 households, 42 samaj were constituted within a short period. Similarly samaj were constituted in Char Nangulia, Noler Char and Caring Char.

Religious institutions are often the first institutions that involve more than one community. People established these on their own initiative and at their own cost, while they provide themselves the required governance. Religious institutions have a positive contribution on society by bringing settlers of different communities together and creating a place to interact with people from other samaj. In practice, mosques and madrassas (traditional religious schools for Muslim children) are invariably among the first institutions in new char areas. This has possibly contributed to the conservative character of the char society at that stage.

Apart from the madrassas, settlers often establish in a later phase primary schools, again on their own initiative and financed by the community. Schools are established in thatched houses built on land arranged by the community, with teachers from the communities themselves. Since the samaj are too small to form a school, the process of school formation is a matter of cooperation between communities. Children of settler families go to the school and that brings them in contact and makes them familiar with the children of nearby communities. Young educated girls and boys from the communities involved teach the students voluntarily or for a small payment made by the community. In all project chars, except Urir Char, CDSP assisted these private schools to become affiliated with the Government, which was accomplished for 16 schools in Boyer Char. In Urir Char the educational institutions were already government related since independence.

Formation of samaj and of religious and educational institutions are important avenues for settlers on the one hand to become part of a wider social network and on the other to maintain or strengthen some sort of identity. These avenues are so to speak home grown, created by the settlers. These early networks have been extremely important in eliminating feelings of uncertainty among the settlers and in developing the first steps towards some cohesion among the heterogeneous groups that migrated to the chars. In many chars, development efforts, financed and staffed from outside, have built on this indigenous process of institutionalization and have taken the initiative to form community based, field level institutions for particular purposes, the subject of the next paragraph.

9.4 INSTITUTIONS INSTIGATED BY GOVERNMENTAL AGENCIES AND NGOS THROUGH PROJECTS

The early networks were essential to provide the settlers with a sense of belonging in their new physical and social environment in the chars. The samaj gave them the security of being member of a community. But on the whole, the institutional network was still weak and governance was very much in the hands of the *bahini* in the absence of formal Government organizations. Development oriented projects as CDSP and GNAEP (later RFLDC) felt it necessary to contribute to the expansion and strengthening of institutions in the chars, by instigating and supporting the establishment of community based, field level institutions.

The Table 9.3 summarizes all the field level institutions formed under the four phases of CDSP.

Table 9.3 Summary of the Field Level Institutions in CDSP-I, II, III and IV Areas

Type of field level institution	CDSP-I	CDSP-II	CDSP-III	CDSP-IV	Total
Water Management Organization (WMO)	WMG(3)	WMG(40) WMA(7) WMF(2)	WMG(10) WMA(1)	WMG(24) WMA(2) WMF(1)	WMG(77) WMA(10) WMF(3)
Sub Polder Committee (SPC)	15		-	0	15
Polder Committee (PC)	3	1	1	0	3
Local Area Development Committee (LADC)	-	5	-	0	5
Farmers Forum (FF)	3	35	35	90	163
Social Forestry Group (SFG)	-	-	114	658	772
Labour Contracting Societies (LCS)	6	-	15	95	116
CBO/Farmers Field School (FFS): RFLDC-Danida				0	0
NGO Group	-	657	341	984	1982
Tube well Users Group (TUG)	229	320	600	1541	2690

Notes: WMG = Water Management Group; WMA = Water Management Association; WMF = Water Management Federation.

9.4.1 Sub Polder Committee (SPC)

When CDSP starts in an area that is meant to be empoldered, the SPC is the first institution that was formed. In principle, each *mouza* has its own SPC. Membership varies from nine to fifteen depending on the size of the *mouza*. Each member of the SPC has to be selected by the people through mass meetings. It is the platform where members at the micro level do the planning of physical infrastructure, including site selection and conflict resolution (for instance in cases of alignment of structures). Settlers present their demands to the SPC, which combine them and refer them to project authorities.

9.4.2 Polder Committee (PC)

The PC is the main communication platform within the polder and between the polder population and the project. Representatives of SPCs (one male and one female from each SPC selected by SPC members) form the PC (with 30% women). The UP Chairman is the ex-officio president. If a polder belongs to more than one Union, the larger Union provides the president. Major tasks of the PC are: coordinating SPCs; endorsing proposals from SPCs; interacting with line agencies and technical assistance staff.

Polder Committee and Sub Polder Committee were transformed into WMOs in CDSP III. They were no longer formed in CDSP IV. Instead directly WMOs were formed as per Guidelines for Participatory Water Management (GPWM) formulated by the Ministry of Water Resources.

9.4.3 Local Area Development Committee (LADC)

In unprotected areas, where no polder was planned to be constructed, LADCs were formed during CDSP-II in the five unprotected areas. One LADC was formed with around 15-20 members in a similar fashion of WMGs bringing two representatives, one male and one female, from each samaj under its umbrella. LADC had similar functions as the SPC in areas that were going to be protected. LADCs contributed in need identification, planning of infrastructure, conflict handling and information sharing in a very transparent and participatory manner. In CDSP IV, LADCs were initially established in Urir Char and Caring Char for limited infrastructural planning, and were later transformed in WMOs.

9.4.4 Water Management Organization (WMO)

Three levels of WMOs can be distinguished: Water Management Groups (WMG), Water Management Associations (WMA, formed by WMGs) and Water Management Federations (WMF, formed by WMAs). The process of formation of a WMG will start with meetings in each water management area, delineated through rapid water management appraisal (RWA). These areas will often be catchment areas of a drainage *khal*. Through mass meetings WMG members are selected, with an equal number of males and females from one area. From the WMG members and by them, a Management Committee will be elected. This Committee will draft by-laws and will look after registration with the Department of Cooperatives. But the Participatory Water Management Rules of 2014 formulated by the MOWR state that. The WMG registration as legal entity must be done by BWDB itself instead by the Department of Cooperatives. Usually WMGs have regular monthly meetings. Once WMGs are established the second tier of WMA can be formed, consisting of office holders of the WMG (bringing four representatives from each WMG). Subsequently, the same applies for the formation of a federation of WMAs as Water Management Federation (WMF). The WMGs are engaged in two types of interdependent activities: water management activities and organizational activities. Average membership of a WMG is around 40, with 60% male and 40% female (in 2018).

The major activities of WMOs are as follows: preparation of an annual plan for maintenance of water management infrastructures; operation and maintenance of sluices; maintenance drainage *khal*s, outfall channels of sluices, embankments, road, bridge/culvert, etc; collection of shares and savings; fund generation through subscription and local resource mobilization, such as works contracted by implementing agencies and operation of public property resources as water bodies and tree plantations; maintaining linkage with BWDB, LGED, LGIs and other local level institutions through formal and informal interactions; providing information to local people on useful topics through posters, leaflets, meetings.

From the field level institutions discussed in this section, WMO is expected to be the most influential one in further development of the chars. It occupies a central place in the whole range of institutions. Its main subject, water management through management, operation and maintenance of water management infrastructures, is obviously a priority in the well-being of char settlers and is directly connected to many of their vulnerabilities.

9.4.5 Farmer Forum (FF)

Following the New Agriculture Extension Policy (NAEP) of DAE (see Chapter 7), the group approach has been adopted in all agricultural extension activities in CDSP. For this purpose Farmers Forums (FF) were established. The objective of organizing Farmer Forums is to enable farmers to make better use of their land in order to increase their crop production. DAE promotes agricultural technologies adapted to saline conditions and resilient to climate change. The FFs have been formed in CDSP areas by DAE in cooperation with local NGOs and the technical assistance team. Each FF comprised 25 to 30 farmers during CDSP II and III, while in CDSP IV the membership increased to 60 in CDSP IV, with 42% female mebers, originating from different clusters of samaj. Selection was done through public meetings. All members, including the women, have indeed farming as their main occupation. The FFs hold monthly meetings. On the initiative of DAE, a Farmers Association was established in CDSP III area in July 2010 as an umbrella organization of the Farmer Forums and as a platform with a connection to the WMGs. During CDSP IV six Farmers Associations were formed in 2014-2015 and in 2016 a Farmers' Federation as per Guidelines for Participatory Farmers Organization (GPFO) was established. All management committees at all tiers of farmer's organization were elected by the general members.

Major activities performed by FFs are as follows: receive training on agricultural extension and technology and disseminate those among farmers; support DAE in establishing demonstration plots; organize field days and participate in exchange visits to other chars; ensure the use and management of equipment and inputs supplied by DAE; maintain linkages with DAE, other agencies, NGOs and other field level organizations particularly WMOs.

9.4.6 Social Forestry Group (SFG)

To ensure people's participation in forestation activities, a social forestry approach has been applied through which settlers are involved in planning, implementation, monitoring, maintenance and management of plantations (see Chapter 4). For this purpose, Social Forestry Groups have been organized by the staff members of the Forest Department (FD), with support of the technical assistance team. They are formed, based on the Social Forestry Rules of 2004 (amended in May 2011). SFGs have been organized for the different sort of plantations: one SFG each for 0,7 km of embankment (both sides), 1 km of road (both sides), 15 ha of mangroves and 10 ha of foreshore plantation. Each SFG has on average 24 members. In CDSP IV, of all members, 62% are male and 38% female. A few criteria for membership are applied, such as closeness to the location of the plantation and priority for landless people and people who are affected by the construction of infrastructure as roads and embankments.

The SFGs have mostly planted timber trees, few fruit species, medicinal trees and coconut palms too. Main activities of SFG were road side, embankment, foreshore, *killa*, institutions and mangrove plantations. The Forest Department has signed benefit sharing agreements with the SFGs. The agreements state the responsibilities of the SFGs in maintaining the trees and stipulate the rules of benefit sharing: the SFG will get 55% of the products, BWDB/LGED 20% (as owners of the land), Forest Department 10%, Union Parishad 5%, while 10% will be kept for re-plantation in a "tree-farming fund".

9.4.7 Labor Contracting Society

The GPWM as well as the National Water Policy (NWP) (see Chapter 1) state that 25% of the earthwork of any public water project will be implemented by Labor

Contracting Societies. The purpose of the LCS program is to create opportunities for employment and income generation for members of the poorest households, both males and females. This is to ensure a fair wage to the labourers and to implement the works in a timely manner and with high quality. In CDSP, the LCSs were involved in earthwork such as repair of embankments, re-excavation of *khal*s and ponds and construction of earthen roads. CDSP IV also engaged LCSs for construction of single pit latrines through DPHE and market development by LGED. WMGs were asked by the concerned Implementing Agencies to form LCSs.

9.4.8 Tube Well Users Group (TUG)

Safe drinking water is a basic need. The installation of deep hand tube wells provides this safe drinking water, and reduces the collection time. A TUG has one female member from each user's household around a tube well. In all CDSP areas these all-female groups have been formed. They are formed by NGOs (with support from DPHE). A total of 2,690 TUGs were established, each with about 15 members. Each TUG selects two caretaker families. They receive training from the NGO. Caretakers are mainly responsible for maintenance of the tube well. Maintenance works include cleaning, monthly opening and washing of the head, checking of nuts and bolts etc. Sometimes, TUGs hire mechanics for major problems. Another function is to serve as a forum for discussion on matters of health and hygiene. The TUGs have developed into key groups in the chars in terms of drinking water and sanitation.

9.4.9 Community Based Organization (CBO)

In the RFLDC project, CBOs are the key institutions for development of sustainable fisheries and livestock extension for resource poor farmers (see Chapters 5 and 6). The CBOs are owned and managed by the community with the characteristics of open membership, democratic governance. They are non-profitable and non-political. Initially, founder members are selected who prepare a constitution. Then application for membership can be made on prescribed forms with recommendations of at least two existing members. The Executive Committee approves the membership. All members elect the Executive Committee with no less than seven and no more than 13 members including the following positions: president, vice president (one or two position), secretary and cashier. The EC should have 2-3 female members. The EC may invite local resource persons to join the Advisory Committee. The CBOs are clustered in District Associations.

Main functions of CBOs are: distribution of agricultural inputs and purchase of agricultural equipments; development of small agro processing facilities; establishment of community nursery for fish and prawn, fruit, vegetables and improved breeding stocks of animals; establishment of artificial insemination facilities, leasing of water bodies; organizing group marketing for agro products; extension services through Farmers Field Schools. The CBOs were formed by RFLDC in CDSP areas using the platform of WMGs.

9.4.10 NGO Groups

In all phases of CDSP, local NGOs were involved. Basically they implemented activities that were complementary to the activities of the Government agencies. In CDSP II and III the local NGOs were coordinated and supervised by BRAC. In Boyer Char (CDSP III) the following five NGOs were engaged: Sagorika, DUS, Hashi, Upoma and NARS. They implemented similar programs, each in about one fifth of the area. The five NGOs have formed 341 female groups (apart from the TUGs, discussed in section 9.4.8), with a membership ranging from 25 to 30. All local adult women are eligible to be a member of an NGO group. The 341 groups have a total of 8,462 members, which suggests that more or less all of the approximately 8,500 households in Boyer Char have been covered. The NGO group forms an executive committee, consisting of a Chairman, a Secretary, Cashier and 9 workers for different components. Sometimes the NGO forms 4 to 5 small sub-groups, consisting of 5 members each, called "*Khudra Dol*".

The NGO component in CDSP III had nine sub-components: (i) group formation and savings management; (ii) health and family planning; (iii) human rights and legal education; (iv) *palli samaj*; (v) poultry and livestock; (vi) social forestry; (vii) homestead crops; (viii) disaster management; and (ix) water and sanitation. NGOs also organized the following forums: Health Forum, *Palli Samaj*, Mother-in-Law Forum, Adolescent Boys and Girls' Forum, Pregnant Mothers' Forum, Students' Forum, Village Doctors' Forum, Local Legal Law Implementation Committee, and Legal Awareness Male Group. They organize short training sessions for the forum members on relevant issues.

In CDSP IV a different institutional arrangement was adopted. BRAC was engaged as one of the partner NGO with other three NGOs following similar process of procurement. Thus in CDSP IV, four partner NGOs (BRAC, SSUS, DUS & SDI) worked to implement the sub-components with equal status. Compared to CDSP III, the social forestry component was dropped, to avoid overlap with the activities of Social Forestry Groups. The NGOs have formed 984 female groups, with an average membership of 25.

9.5 EMERGENCE OF GOVERNMENT

Based on the policy of the Government of Bangladesh to transfer all newly accreted lands to the Forest Department for afforestation for a period of twenty years, forestry officials are the first sign of government presence in those remote areas. When illegal occupation of forest land started by migration of settlers, guided by *bahini*s, a tense relation usually develops between the settlers and the Forest Department staff. This is an unfortunate starting point for the relations in general between char settlers and government.

At the time of accretion of the char land and for many years after occupation of the chars by settlers, these areas are institutionally speaking virgin territories. State agencies, except then for the Forest Department, are not present while the commercial private sector is limited to small shops. In some areas NGOs have set up a branch office for implementation of small programs, often geared towards disaster mitigation and drinking water supply.

Apart from the tense relations between settlers and government and the virtual absence of government, also the uncertainty about the jurisdiction of new land contributes to the overall institutional picture. Because chars are recently formed lands, the jurisdiction over them in many cases becomes an issue (see Chapter 8). In practice, in the areas where CDSP has been and is operational, there have been boundary problems between Districts, Upazilas and Unions. The mechanism to solve such boundary issues is not well developed. Adjustments in the government machinery have to take place to facilitate this process of conflict resolution and to give government a smooth and fair start in making its presence felt in the chars. This applies both to the bureaucracy and to the elected local government bodies.

9.5.1 Local Government Institutions (LGI)

Local government institutions not only face the challenge of uncertainty of the administrative status of newly emerged chars. If boundaries are clear and agreed upon, they also have to face the fact that a large number of people and considerable land areas are added to their jurisdiction. Their staff and resources, meager at the best of times, are not adequate to cope with the changed circumstances. Their normal management– and development functions are clearly hampered in the newly added remote and often difficult to reach areas.

A Union Parishad is the agent of the Government at local level for "management of local affairs". Besides being a forum for participation of people in local democracy, as the local government institution, it is expected to deliver or to assist and cooperate with appropriate agencies that can deliver goods and services that are most basic for livelihood of the people within its jurisdiction, which include arrangements of drinking water, sanitation, health services, education, and law and order.

As far as their role in water management is concerned, the local government institutions (UPs, Upazilas) will provide coordinating, supporting and facilitating assistance to the concerned WMOs in respect of participatory water management at local level. Union Parishads will provide such assistance through their representation as advisers to the concerned WMOs. Also, on behalf of the Union or Upazila Parishad, the Standing Committee on agriculture, irrigation and environment can provide such facilitating support.

District Development Coordination Committees and Upazila Development Coordination Committees can serve as forums for discussing water management issues. If WMO representatives are co-opted in such forums, these discussion would be even more valuable. In practice it is seen that some WMO members are also UP members, or even UP Chairmen. WMOs can also raise their issues at those meetings through the concerned UP/Upazila Chairmen or staff of BWDB, LGED, other agencies and also NGOs with whom they are in close contact.

The LGIs can also support the WMOs by allocating some funds for O&M of water infrastructure. They can, for example, take up some maintenance works (e.g., cleaning of *khal*, re-excavation of, etc) with funds from their development budget or from special programs. LGIs could lease out drainage *khal*s as fishing grounds to WMOs in order to generate resources for O&M. This all depends on the relation between the LGI officials or LGI Chairman towards the WMO. WMO members that are elected in LGIs are well placed to develop such a linkage.

Efforts are underway to further develop partnership at local level in particular with regard to water management issues. A process has started to formalize the participation of LGI representatives in WMA meetings and participation of WMOs representatives in UP coordination meetings.

9.5.2 Government Agencies

In the initial stages, Government agencies are totally absent in newly emerged chars, with the exception of the Forest Department. Over time state agencies are becoming visible in populated areas. When land is available for allocation to landless households, staff of the land registration and land settlement offices are the first to appear in the chars. They are often followed by personnel from infrastructure oriented departments as BWDB, LGED and DPHE, certainly if a development project as CDSP is introduced.

In case of CDSP, the project is sponsored by the Ministry of Water Resources (MoWR) and is implemented by the Bangladesh Water Development Board (BWDB) as lead agency, the Ministry of Land (MoL), the Local Government Engineering Department (LGED), the Department of Public Health Engineering (DPHE), the Department of Agriculture Extension (DAE) and the Forest Department (FD). For the activities and funding of each of these six agencies a separate Project Proforma is formulated and approved. a technical assistance team provides support to all agencies. A unique achievement of CDSP is the active cooperation and coordination between six Government agencies and the structured relationship between Government agencies and the NGO activities in the same area. The policy level coordinating body of the project is the Inter Ministerial Steering Committee (IMSC), chaired by the Secretary of the Ministry of Water Resources, with representatives from parent ministries of the implementing agencies, and of the water/irrigation wing of the Planning Commission. The Project Coordinating Director (PCD) for BWDB acts as Member Secretary of IMSC. A representative of the donor agency and of the technical assistance team participate as observer.

At the project level the Project Management Committee (PMC) is the central coordinating and management body. It is chaired by the Project Coordinating Director (PCD) of the lead agency (BWDB), while the Project Directors of the other five participating agencies and the Team Leader of the TA Team (as Member Seretary) are PMC members. The technical assistance team provides secretarial support. For all practical purposes, the management of the overall project is in the hands of the PMC. The PMC meets each month.

The general picture is that, after very little presence in the first period after settlement, the influence and amount of activities of state agencies increase dramatically. Their involvement is a necessary factor in bringing security for the settlers and in creating opportunities for further social and economic development. It has been a merit of CDSP that it acted like a "trailblazer" so to speak by starting activities in hitherto marginalized remote areas, with six Government agencies and local and national NGOs, and, as a secondary impact, initiated a process of drawing in other institutions in its slipstream. This counts for both the private and public sector. Markets are established, suppliers from outside the chars open branches, banks open an office and other Government departments, as for instance Education and Health, are making their presence felt.

9.5.3 Members of Parliament (MP)

Although MPs do not frequently visit new char areas, such movements become more frequent towards time of election. Char settlers have become an attractive voters block and char development can count on broad based political support. Well to do MPs have invested their own money in basic services in chars such as tube wells for drinking water and small rural roads. In the day to day practice of development activities, MPs have made a positive contribution by playing a constructive role in cases of conflicts between people from different areas and or between different parts of the bureaucracy. In solving boundary issues, the involvement of the concerned MPs is virtually indispensable.

Another function of MPs is to identify typical coastal issues and to take them to the national level. Local MPs have regularly raised char related issues in Parliament. Recently there has been a development in the formation of a group of MPs, hailing from coastal constituencies, to lobby for matters related to coastal development and climate change. This is a positive development, as long as the established systems are informed and the almost natural tension between politicians and the bureaucracy is not further increased.

9.6 OVERALL PATTERN OF RELATIONS BETWEEN INSTITUTIONS IN THE FIELD

There is no formal framework for coordination among the field level institutions as the WMOs, SFGs, FFs and NGO groups. WMOs can form associations and federations, but there is no structured linkage with other groups in the same char area. In practice, links exist because of overlapping memberships. Of the 368 members of WMGs in Boyer Char, 35 also participate in SFGs and around 100 in FFs. A similar phenomenon can be observed in other chars such as Char Nangulia, Noler Char, Caring Char, Char Ziauddin and Urir Char. Establishing a platform where coordination can take place and ways of cooperation can be identified, is something worth considering for future char development programs. The chances for duplications and misunderstandings would be further reduced. One should be aware however of “bureaucratization” of the dynamics at field level. A first step could be to create an umbrella for all SFGs and a separate one for all FFs. At polder level, a rather loose framework could be formed coordinating the groups coming from the different sectors (water management, agriculture, forestry, aquaculture etc.). In fact, the Farmers Association as formed first in July 2010 in CDSP-III and later in CDSP IV, bring members of WMGs and FFs together.

Overlapping membership applies also in the relation between Union Parishads and field level groups. In the combined CDSP areas, a notable number of UP members are member of WMG/WMA and one UP Chairman is the President of WMG. The relation between community based institutions and local government has been described in the previous paragraph, in particular with regard to the key issue of water management. Operation and maintenance is the main subject to be dealt with in this relation. The same can be said of the relation between the field level institutions and state agencies as BWDB and LGED. These agencies have established instruments for coordination among themselves such as the Development Coordination Committees at Upazila and District-level. In case of CDSP, the Project Management Committee (see previous paragraph) serves as coordination platform among Government institutions and between them and NGOs.

In the char areas of southern Noakhali, the coordination between the different development projects has proven to be very effective and fruitful. Regular informal and formal meetings between, for instance, CDSP and RFLDC have led to a distribution of labour between those projects in certain char areas (CDSP is not primarily involved in aquaculture and livestock as such, but does create water bodies where aquaculture can be practiced; under CDSP WMOs have been established, that have been instrumental in forming CBOs for aquaculture and livestock). The Danida supported rural roads program actually was the first project to start activities in Boyer Char, Char Nangulia, Noler Char and Caring Char, with much needed improvements in communication, using the feasibility studies produced by CDSP. Also the Danida funded water and sanitation program established test– and consumer tube wells in those areas, before CDSP began actual activities. This coordination is stimulated and supported by the District administration. Meetings chaired by the Deputy Commissioner or one of his staff members take place on a regular basis.

In a sense, the ultimate coordination and integration of all the institutions that are active in the char takes place at the level of the settlers themselves. Asked about the relative importance to them of the different groups, representatives of samaj in different parts of Boyer Char, Nangulia, Nolerchar, Caringchar and Char Ziauddin mentioned the WMO as the most useful community based institution in the area. NGO groups followed as second and Tubewell User Groups as third. Social Forestry Groups, Farmers Forums and Labor Contracting Societies came in last. The agencies working together in CDSP are generally positively viewed. It is felt that those agencies work indeed for the poor and deliver infrastructure and services of good quality.

9.7 SOCIO-ECONOMIC TRANSFORMATION

Justified questions are how the settlers fared in terms of bread-and-butter issues (section 9.7.1), how interventions addressed their set of vulnerabilities, including their position in the struggle for control over natural resources (section 9.7.2), and how interventions impacted the existing gender bias (section 9.7.3).

9.7.1 Economic Benefits and Access to Social Services

Economic Benefits

The bulk of the economic benefits for char dwellers stems from the changes in agricultural production. In the protected areas, in general, one can observe a higher cropping intensity, roughly from around 115 before the start of the project activities to over 200 after about 10 years (intensity of 100 equal's one crop per year in a particular area). The higher intensity is a consequence of larger areas that can be used for *aman* (paddy) crops (because of improved water management), but more so because of an expansion of the area under *aus* (paddy) crops (better water management and gradual decrease of salinity) and *rabi* crops (less salinity and availability of water in ponds in the winter season). In addition to this expansion in cultivated area, there was a discernable shift from traditional to high yielding varieties, resulting in higher yields per hectare. For *aman* rice the increase in yield has been from roughly 1.5 ton per hectare to three and in some areas even above four tons per hectare. Also homesteads were developed and they produced more fruits and vegetables than before project activities started.

In the first years after people moved into the newly formed chars, they were reluctant to invest in livestock nor were farmers from outside the area willing to let their cattle graze on the chars because of the lack of security. Over time however, rearing livestock has become a profitable source of income and probably provides the most important source of livelihood in the isolated, unprotected areas. The isolation is a constraint for efforts to improve the rearing systems. There is some confidence that the issue can be addressed through simple technical improvements through Farmer Field Schools.

There are considerable pressures on wild fisheries due to a variety of reasons, such as sedimentation, overfishing and worsening weather conditions. The creation of polders further restricts the possibilities for open fisheries. But aquaculture in ponds and other water bodies offers a huge economic potential for the settlers, if appropriate support is provided.

Also forestry is a source, albeit modest, for additional income for the settlers. The social forestry approach, with the benefit sharing agreements, has began to bear fruits in the efforts of the char population to have a decent livelihood.

The infrastructural development, in particular the road network, made it possible to sell the produce not consumed in the household, and to buy other goods and services. All over the chars markets have been developed, very often as a result of local initiatives, sometimes with project support (for instance the Market Infrastructure Development Project in Charland Regions, MIDPCR). In Boyer Char, an area of 6,600 ha., 23 markets are existing, with an estimate of 1,000 large and small shops doing business. In CDSP-IV areas, seven village markets were completed under the project. Future growth of these markets can be expected. Apart from the permanent shops, one big bazaar acts twice a week as "haat", a wholesale market where farmers bring their produce. Traders and middlemen, with links to Dhaka and other much bigger markets, buy directly from this market. This generally has led to higher selling prices for produce from char areas. At the same time, the prices of goods imported from outside the area, such as processed goods like grocery items and medicines and agricultural inputs as seeds and fertilizer, have come down. This is largely due to the reduction in transportation costs and the increase in competition.

The uptake in agricultural activities and trade has fueled other economic activities as well. Banks have become interested and have opened branches in the char areas where development is taking place. Small workshops are being established. The availability of transport facilities as rickshaws and buses has dramatically increased, substantially improving the communication from new chars to Upazila–, District centers and to Dhaka (there is a direct bus service between Boyer Char and the capital). The economic base was further strengthened by the skill development of the char dwellers through a variety of training programs. All these developments have created employment opportunities for people in Boyer Char (CDSP-III) and five other Chars under CDSP IV. Jobs were lost however, to a very limited extent, through the loss of wild fishing activities in those areas where embankments have been built and *khal*s have been closed.

Diversification of Source of Income

This process of economic transformation is in line with the trend of diversification that can be seen in other areas in the country as well. Rural households are no longer only involved in farming practices but increasingly derive incomes from non-agricultural sources. The plot of maximum 1.5 acre (nearly 6,100 square meters, or a piece of land of 78m by 78m), that a hitherto landless household is allotted in the chars, is not adequate to provide a sustainable livelihood. Although the percentage of people with a food shortage declined substantially (from about 40% to 20%), food insecurity is still a major issue for many. Especially the November/December period, when rice stocks are depleted, and the July/August period, with low local demand for labor, are difficult times for char dwellers. They have to look for additional sources of income and are forced by the circumstances to go for diversification. Many men migrate seasonally to cities as Feni, Chittagong, Dhaka and other main land areas to make additional money as day laborer.

Access to Social Services

Social services as such were not a major thrust in the most significant development interventions in the chars. They were all more or less geared toward development of infrastructure and economic activities, including institutional changes at community level connected to these subjects. A part of the infrastructure is directly related to social services, with a strong health orientation: the construction of deep tube wells for drinking water and the distribution of sanitary latrines and public toilets. For more or less each 15 households a deep tube well is sunk. To avoid salinity and arsenic contamination, the tube wells go as deep as 800 to 1200 feet. In areas where even at that depth no good quality water is found, sand filters on community ponds and rainwater harvesting schemes are installed. For each tube well and each sand filter, user groups have been formed that are responsible for operation and maintenance. They also have the task to contact and influence the Department of Public Health Engineering if major repairs are required. Each household is provided with a latrine. At markets public toilets have been constructed.

The supply of drinking water and the provision of sanitary latrines obviously have strong health connotations. The same can be said of the higher variety of crops, fish and livestock products. But in the overall scheme of development of chars, health care services remain a weak link. As a general rule, the farther away from the Upazila or District headquarter, the more underserved the area is. Remote parts, as for instance South Hatiya, are still dependent on pharmacies and village doctors, while areas closer to or connected with the mainland have access to clinical health services. In some cases, cyclone shelters are used as health center. In the NGO-programs, social services have featured more prominently. Health and family planning, legal and human rights and water and sanitation were sub-components of the work of the local NGOs under CDSP. The general trend however is that, over time, the provision of health care services from the side of the Government increases in the char areas, sometimes in collaboration with an international NGO (Save the Children).

There is an indirect relation between the new infrastructure and educational services. A common phenomenon in the chars is the establishment of primary schools as a result of initiatives of the communities themselves, completely without any outside help. Teachers are members of the community and costs are paid out of contributions from the settlers themselves. It shows their determination to see that their children are taken care of. These schools are housed in thatched structures, without much facilities to speak of. Cyclone shelters are meant as multi-purpose buildings and can house schools. In most cases, this is indeed what happens. In Boyer Char, Char Nagulia, Noler Char, Caring Char and Char Ziauddin, all cyclone shelters have been designed with the school function in mind: they have built-in black boards, designated teachers' rooms, while the tender for the building includes school furniture, as well as drinking water– and sanitation facilities. CDSP has assisted the schools in the time-consuming process of registration with the Government. Legal use of a cyclone shelter, a state owned building, is not possible without registration. For support from the Government to schools, registration is a requirement as well. The pressure from the population is now redirected to the availability of secondary schools.

9.7.2 Impact on Vulnerable Position of Settlers

The combined impact of these changes can probably best be summarized as more security and less vulnerability. Economic security through higher production and better marketing facilities; physical security through the construction of peripheral embankments, a road network and cyclone shelters; legal security through the provision of land titles. The departure of the muscle men, the ushering in of community based organizations that also served as vehicles for conflict resolution, the presence of the Government administration, the establishment of required police stations and better communication with the outside world, caused a dramatic improvement of the law and order situation on char lands.

The higher institutional density (increase in presence of government, as well as birth and growth of a series of field level, community based organizations), the greater social cohesion among the households, the progress in economic terms, and the slightly higher availability of social services, have in concert over the years led to a vastly different socio-economic scenario. It is safe to say that development efforts have resulted in more vibrant and stronger char communities. The social fragmentation has decreased, and the set of vulnerabilities is less threatening than it used to be. The formation of groups, especially the Water

Management Organizations, and to a lesser extent the Social Forestry Groups and Farmers Forums, have strengthened the position of the settlers in the struggle over control of natural resources. The fact that households received titles on the land they occupy meant a great leap forward and gave them control over a key natural resource. The struggle has now shifted to keeping control over their land, to having their fair share of water resources, and to equity in the sharing of benefits of public lands. The position of the settlers in that struggle vis a vis other actors (as state agencies and commercial interests) is much firmer for a number of reasons. The community based organizations stimulated cohesion and fostered an atmosphere of cooperation, of solving conflicts in a peaceful manner. The security of having a land title instilled self confidence. The people are much better informned about their rights and now know the ways how to pursue them. The fact that they are economically much better off, gave them room for maneuvering, because it made the people much less dependent on the old powerful clique for employment and credit.

Assessing the impact in the oldest CDSP areas, about twenty four years after the first phase started, it can concluded that not all original benefits have proven to be sustainable. The growth in population, both autonomous and through additional immigration after the polders were completed, has led to pressure on access to services and production factors. Although the large majority of households managed to keep the land they received after settlement, in practice control over land through distribution among siblings of the same household has to some extent be fragmented. Urbanization of rural areas can be seen around the larger markets. The in-migration in these areas has most probably slowed down the migration to large urban areas as Dhaka and Chittagong. However, even with this dilution of impact in the older CDSP areas (in particular CDSP I and II), the percentage of very poor households is estimated to be significantly less than before the interventions started. In 1993 around 90% of households could be characterized as very poor, while in 2010 40% was seen to belong to this category.

One can say that in many ways, the remote chars of the beginning of the 1990s have turned into areas not unlike the rest of Bangladesh, and indeed have moved out of the periphery into the mainstream. The developed chars are, however, in the advantageous position of having recently constructed infrastructure of, in general, good quality. The attention for operation and maintenance issues is possibly greater than in the average area elsewhere. The inhabitants have organized themselves into community based organizations that have an essential role in this respect. In these char areas, an institutional culture has been introduced of cooperation between state agencies, communities and local government bodies. And the interests of these remote areas are being taken seriously at the national level of bureaucracy and politics.

9.7.3 The Gender Issue

The Position and Status of Women on the Coastal Chars

The female population of the coastal chars is generally characterized by high levels of poverty and disempowerment. Women are among the most vulnerable members of society and make up a large percentage of the extreme poor. This is particularly true for female headed households, which are relatively overrepresented on the coastal chars due to male out-migration, and high levels of divorce and abandonment of women by their husbands. Other factors that play an important role in this regard are the poor health conditions and health care, as well as the lack of law and order in char areas. Women often lack choice, voice and skills, which is inextricably related to their vulnerable economic position and further contributes to their marginalization and exclusion. As a result, women often find themselves in an extremely disadvantaged position and are characterized by a downgraded social status in comparison to men.

Women's disadvantaged position and low social status is reflected in many aspects of their lives, and can be explained by the socio-cultural as well as the economic context of the coastal chars. As argued in section 9.3, coastal char communities are relatively conservative. They are characterized by the existence of strong patriarchal social structures and system of purdah. Purdah literally means "curtain" or "veil" in Bengali. It refers to the Muslim practice of female seclusion and isolation from men outside their immediate family, and can be expressed and exercised in many different ways; including the physical segregation of women from men in the public and private sphere, and the concealment of women's body and face with a burkha.

As a result of the existence of strong patriarchal social structures and a system of purdah, char women face many restrictions. They often carry the full responsibility for domestic work and are severely limited in their mobility, which hinders their participation in economic activities and contributes to women's strong dependency on men for their survival and that of their children. In addition, women are usually excluded from ownership of property (including land) in their marital home and are withheld access to parental property. This can be explained by local traditions as well as inheritance laws, that determine males the main inheritors of property. Due to their lack of ownership of property, income-earning power and mobility, women have limited personal autonomy and decision-making power in the public as well as the private domain. Furthermore, many women are victims of gender-based violence, discrimination and oppression. They often have limited control over their own lives, experience high workloads and are characterized by a low nutritional status. The female population on the coastal chars is also deprived of basic health care and education, which puts their lives in serious danger and impedes their chances of a better future.

The Impact of Development Interventions on Char Women's Empowerment

Development interventions over the past decades have had an important impact on the position and status of women on the coastal chars. Important interventions in this regard have been the organization of char settlers (including women) in groups, the provision of *khas* land to landless households and gender awareness raising activities.

As outlined in section 9.4, development projects, in collaboration with governmental institutions and NGOs have played an important role in the formation of groups, like WMOs, FFs, SFGs, LCSs, TUGs, CBOs and NGO groups. Under CDSP-III, women accounted for 47% of WMO members, 30% of FF members and 38% of SFG members. In CDSP IV these figures were 42%, 42% and 41% respectively. Although women's participation in these groups is not yet equal to men, these figures represent great achievements by the project, as such groups usually predominantly or completely consist of male members. TUGs and NGO groups in the project are 100% made up of women. By encouraging women's active and more equal participation in groups, projects like CDSP aim to ensure women's benefits from development interventions and contribute to an improvement in their position and status. Women confirmed that their social prestige was increased by their membership of a field level institution. The linkages between female members of these groups had a tendency to have a greater impact, influencing a wider circle of social and political activities. It is expected that these networks will sustain after CDSP discontinues its activities.

In a series of workshops with female members of field level institutions in CDSP IV, the impact of the major project interventions on their lives was considered to be very positive, across the board. The highest scores were given to the installation of tube wells and latrines, to the construction of cyclone shelters, roads and bridges, to the support for crop production, and to the provision of land titles.

As far as the roads are concerned, the mobility of women indeed increased significantly. According to their own assessment after CDSP-IV completed its interventions, regular visits to, for instance, local markets (as buyers and as sellers), homes of relatives, the Upazila centre (shops, offices) shot up from almost zero to between 40% and over 80%.

The provision of *khas* land to landless households is aimed at strengthening livelihoods and reducing levels of poverty on the chars (see Chapter 8). Usually, the *khatian* is provided in the name of both spouses; listing the husband first. CSDP however, is the first and up until now probably only project in Bangladesh where women's names are being put first on the *khatian*. This recognition of women's land rights is aimed at increasing their power of ownership and improving their position and status.

Awareness raising activities have often been aimed at sensitizing the char population towards important gender issues, like the disadvantaged position, rights and needs of women and girls, in order to reduce levels of discrimination and maltreatment experienced by them. Important topics in this regard are gender-based violence, dowry, early marriage and women's health.

As a result of different development interventions, char women have been enabled to diversify and often significantly improve their livelihoods. Important in this regard have been skill development trainings and input support provided by NGOs and projects like CDSP. Female members of NGO groups formed under CDSP for example, receive training on homestead crop cultivation, poultry rearing and livestock rearing, as well as inputs in the form of free vegetable and fruit tree seeds. Furthermore, the project has trained women as community health workers, birth attendants, poultry workers, horticulture nursurers and human rights and legal education workers, and included them as construction workers in LCSs. As a result of these and other types of interventions, the female char population has been provided with important income earning opportunities. In combination with their improved access to saving schemes and micro-credit loans, this has resulted in an increase in women's income-earning power. Many char women are now better able to meet their households' needs, and find themselves in a less vulnerable and economically dependent position.

The increased income earning opportunities for women was definitely one of the factors that lead to a dramatic fall in incidence of poverty. A self-assessment among women that the share of very poor households decreased from 72% at the start of the project to 43% after the project was completed, and of poor households from 52% to 33%. Many of the very poor and poor families were women-headed households.

Various development actors have also directed efforts towards improving the state of education and basic health care on the chars. This has had an important impact on the female population. The majority of pupils (70%) of BRAC's non-formal primary education schools in Boyer Char for example, are girls. In the CDSP IV project area (Char Nangulia, Noler Char, Caring Char and Char Ziauddin) the enrollment of girls in non-government primary schools (established in cyclone shelters) was 48%. In these chars a significant number of madrassas were established, with female enrollment figures similar to that of the primary schools.

In surveys in CDSP IV, women have pointed out that due to higher incomes and better road communication, there is an increase of expenditures on health care. They also mention the beneficial effects on the health of women and children of the installation of tube wells and latrines. Furthermore, many women and girls have experienced an improvement in their reproductive health, due to increased family planning services and to a better pre– and post-natal health care provision on the chars. Altogether, these improvements in access to basic services like health care and education have increased females' chances of a better future.

The provision of official land titles to women and their households has also had far reaching consequences. Not only has it contributed to a significant increase in their asset base and economic security, together with women's increased income-earning power it has also contributed to an improvement in their bargaining position and hence decision-making power within the household. Many char women have experienced an increase in their influence on decisions concerning land, as well as other economic decisions, like those regarding the use of their earnings and expenditures for health care and education. This is also true for non-economic decisions, such as those concerning family planning and the marriage of children. Men are now more likely to consult with their wives and consider their opinion when taking decisions, as women have become of greater economic value to the family. Another important reason for women's increased influence in decision-making processes is their enhanced ability to speak up. Due to their improved position and increased awareness of women's rights and responsibilities, the female char population has started to demand and exercise greater influence in decision-making processes affecting their lives and that of their families. This is true for decision-making processes at the household as well as community level. It must be added that there is still some distance to go to come to equal influence of men and women in major household decisions. Particularly important for women's increased influence at the community level has been their participation in groups, as it has resulted in an increase in female mobility and social solidarity, and provided women with valuable opportunities to raise their voice concerning public matters and develop themselves into community leaders.

Women's land-ownership, increased income-earning and decision-making power, as well as group membership have also contributed to an increase in their economic as well as social status within the household and community. As a result, many char women receive better treatment from their husbands, families and community members. This is for example reflected in the significant decrease in gender-based violence, a stark marker of inequality in power relations between men and women. Important in this regard have also been gender awareness raising programs. Furthermore, women's stronger economic position and improved status have also contributed to a reduction in divorce, abandonment and polygamy.

It can be concluded that development interventions have contributed significantly to processes of female empowerment on the coastal chars. As a result, women's lives have improved and a more gender balanced and equal society has been created.

9.8 CONSIDERATIONS FOR FUTURE DEVELOPMENT PROGRAMS

Participative Land Management System in Period of Afforesttation

As was seen in other chapters as well, the autonomous migration into new chars guided by *bahini*s that work for the interests of a few powerbrokers, comes with many disadvantages and deprivations for the migrants themselves. The government is conspicuous by its absence. This could possibly be obviated if a land management system with a large element of people's participation and of involvement of the District administration would be in place during the period of afforestation of newly emerged land.

Coordination Amongst Field Level Institutions

To foster coordination between the different field level institutions and to avoid any sort of overlap, it should be considered to create a rather loose umbrella framework or platform where the groups from different sectors can come together. This would be in addition to the connection between the groups by double membership and to the coordinating role of the local government, in particular the Union Parishad and the Upazila Parishad.

Local Government Institutions

Future programs should include more targeted support for the functioning of the local government institutions. This could range from training efforts to exchange visits to other areas in the coastal zone and focused information campaigns. The position of female elected members in the respective parishads should in particular be strengthened.

Cooperation Between Projects

The cooperation between projects as initiated in southern Noakhali has proven to be fruitful and deserves to be replicated and to be formalized to a higher degree in future development activities. A pro-active role of the District administration would facilitate this process.

The Institutional Model of CDSP

With a view on its results, the CDSP-model for coordination among state agencies and between state agencies and NGOs can serve as a best practice model for future programs. At the heart of the model are elements of integration and participation, while the impact of the project on livelihoods of char settlers has been positive.

Improved Livelihoods and Self-Confidence

Economic growth and access to social services have contributed to the self-confidence of settlers, both female and male, and have made their bargaining position in the control over natural resources stronger. Higher production and practical improvements in livelihoods of people are indispensable components in any program that aims at development in the chars.

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Chapter 10

Coping with Climate Change at Community Level

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10.1 INTRODUCTION

During the past decade, the Asian region experienced the highest incidence of climatic disasters in the world. Low lying and densely populated coastal areas, including in India and Bangladesh, are extremely vulnerable, especially in the context of climate change induced migration and displacement. Although with better preparedness and coping mechanisms the death tolls have drastically reduced, Bangladesh still has one of the highest numbers of loss and damage caused by floods and cyclones.

In the coastal zone of Bangladesh, a wide range of vulnerabilities have been identified: cyclones and storm surges; salinity intrusion and sea level rise; floods and waterlogging; land erosion and dislocation; degradation of unique coastal ecosystems; loss of habitats and biodiversity; widespread poverty and limited livelihood opportunities; highly unequal social structures and conflicts over resources; poor access to many forms of infrastructure and technologies.

These vulnerabilities affect the livelihoods of coastal communities. Most impoverished coastal households face multiple vulnerabilities that reinforce each other in terms of both the impact of specific events and the capability to recover from these events when they do strike. For instance, poor infrastructure and remoteness of many coastal localities mean that the immediate impact of a major cyclone is likely to be more severe with delayed relief efforts. Subsequently, when survivors are rebuilding their livelihoods after the disaster, poor access to markets, credit and other services, institutional weaknesses and the deterioration of the coastal resource base hamper the recovery process. These vulnerabilities affect different households differently.

Research results have indicated that vulnerability is gender biased, i.e., women are more vulnerable than men. In addition to being vulnerable physically vulnerable, it is their social standing and dearth of income generating opportunities that adds to their burden. Women are often the ones who are “trapped” in vulnerable and ecologically fragile areas, because their mobility is restricted and they do not usually migrate to cities for alternative incomes. Because of their role as nurturers, women also bear the brunt of their children's well-being, which becomes challenging during and after disasters.

All quarters of society now unanimously agree about the reality of climate change and associated disasters and their manifold implications for the lives and livelihoods of the vulnerable communities living along the coast. The effects of climate change on coastal resources will add to the reduction of the economic potential and employment opportunities in coastal areas, already under stress by the occurrence of cyclones and storm surges. It is imperative that adaptation strategies are pivotal in identifying and formulating Bangladesh's future development programs. This chapter offers an overview of a number of government and non-government led Community Based Adaptation (CBA) initiatives in Bangladesh, primarily by drawing on empirical evidences from the southern shorelines.

10.2 CLIMATE CHANGE: SCIENCE, POLICIES AND PERCEPTIONS

The impact assessments of the Intergovernmental Panel on Climate Change (IPCC) identify Bangladesh as one of the most vulnerable countries in the world. As a low-lying, densely populated coastal area, Bangladesh is already experiencing recurrent storm surges, flash floods and cyclones, which will cause widespread damages to infrastructure and ecosystems. The World Bank estimated that a total of 21.1 million rural people will be at risk of inland flooding if inundation is greater than 0.3m by 2050. In the case of storm surges, it was calculated that nearly 17 million people in the coastal zone will be exposed to coastal flooding and inundation depths greater than 1m. Over 400 million people are dependent on the coastal and marine resources of the Bay of Bengal region. Urbanization, population boom, over-exploitation of resources, unsustainable practices, changes in land-use and recurrent natural disasters has rendered these communities vulnerable.

Following the publication of IPCC's Fifth Assessment Report (2014) and analyzing the impact of super cyclones such as SIDR (2007) and AILA (2009) in Bangladesh, the correlation between climate change and frequency, intensity and magnitude of disasters became obvious. The Government of Bangladesh has been responsive to climate change by formulating national plans and policies and channeling resources to finance adaptation in vulnerable areas. The country became a global pioneer and testified its commitment to combat climate change in the "Bangladesh Climate Change Strategy and Action Plan (BCCSAP)" in 2009. Climate change adaptation and mitigation have been integrated into the country's national development agenda, in the 7th and 8th Five Year Plans. The Bangladesh Delta Plan 2100 gives ample attention to climate change and its consequences.

While climate change can be attributed as a major driver of migration, it is compounded by social, economic, political and structural factors. Resources, cultural ability to cope with change and gender contributes to the decision to migrate or not. A research conducted on internal migration in Bangladesh revealed that many of the respondents had migrated due to lack of income generating opportunities and landlessness induced by natural disasters. The floods of 1988 and 1998, cyclones SIDR and AILA and riverbank erosion were mentioned as the landmark environmental events that affected displacement.

Various approaches to analyzing vulnerability exist, both quantitative and qualitative. Certain vulnerabilities for some groups of people may be reduced, either through people's own actions like reaching a cyclone shelter on time, or through the actions of government and local authorities such as building cyclone shelters. Reductions in vulnerability may be used as indicators of development progress, keeping in mind that vulnerability varies widely across communities, sectors and regions. Equally important in terms of ascertaining vulnerability are both science and the perceptions of the vulnerable communities.

In a research carried out in 21 unions (administrative unit) of the coastal district of Noakhali in Bangladesh, the perceptions of the local people and the observed changes in climate were recorded as follows: short duration incessant rain; changes in the rainfall patterns; increase in temperature; regular occurrence of drought; intense winter with dense fog; higher levels of salinity intrusion in soil and water; untimely floods and waterlogging; greater frequency of cyclones and storm surges.

10.3 ADAPTATION: UNDERSTANDING AND APPROACHES

The main findings of a Participatory Vulnerability Assessment (PVA) exercise in Noakhali, aggregated for all 21 Unions, recapitulated that people's vulnerability was compounded by many other factors such as lack of infrastructures and limited access to basic services such as healthcare. Over the years however, coastal people have acquired coping strategies to adapt. These strategies cover a broad spectrum of activities; some focus on preparedness, while others enable them to tackle the aftermath of disasters. The role of local government agencies is one of the most important factors in promoting adaptation to climate change and reducing vulnerability. This is true across all sectors, but community members have especially mentioned sectors such as agriculture and disaster management, where local agencies can play an instrumental role in facilitating adaptation to climate change.

Community Based Adaptation (CBA) approaches to climate change adaptation have gained much popularity in recent years. Increasingly, planners, implementing agencies and policy-makers are adopting "integrated" CBA approaches in their projects and programs. Learning from past experiences have revealed that scaling up CBA through mainstreaming, replication and diversification in different livelihood sectors indeed reach the vulnerable communities most affected by climate change.

As per definition CBA is the identification and institutionalization of mechanisms that allow the most vulnerable local communities to cope with climate change. CBA is a bottom up approach by which a community is positioned as the main entity to implement adaptations and increase adaptive capacity. Community-based initiatives to achieve success have included the following elements: institutionalization of Community Based Organizations (CBOs), resource management, income generating activities through capacity building, networking, wide stakeholder support, legal aid and policy development.

The communities themselves are the major stakeholders in any adaptation effort. They face increased health concerns, fall in food security, fluctuating economic activity and a decline in natural resources and heightened stress on physical infrastructure as a result of climate change. The involvement of the local community in adaptive measures is important for the dissemination of knowledge regarding climate change. Adaptation must be a common effort, based on building alliances amongst stakeholders. It requires involvement of local as well as national institutions taking part in the planning efforts at the local, regional (sub-regional) and national levels with a primary focus on serving the national development agenda. It is of utmost importance to involve local communities in the accumulation and dissemination of appropriate adaptation strategies that are harmonious with indigenous knowledge and local technologies.

Participatory Vulnerability Assessment (PVA) is a tool that builds on the principles of CBA by recognizing that local communities have to be intimately involved. PVA requires participation of partners and stakeholders in the area where it is being conducted. The success of PVA depends partly on the diversity of stakeholders involved because their actions can exacerbate or reduce vulnerability. Experience has proven that it is rewarding to start at the micro level, with a smaller team, and scale up afterwards. The CBA examples include both soft and hard measures, ranging from awareness creation to construction of resilient homesteads.

Akin to CBA, Ecosystem-based Adaptation (EbA) is another approach that encapsulates a broad set of principles for adaptation to climate change. EbA approaches have been deployed in several projects by national and international development agencies and involve the management of critical ecosystems and their services to reduce the climatic vulnerability within local communities. Nature-based Solutions (NbS) is yet another similar approach which identifies actions to protect, sustainably manage, and restore natural or modified ecosystems; systems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits.

In Bangladesh, all of the different CBA approaches to adaptation are currently in practice, in order to understand and address climate induced vulnerabilities of the communities in peril.

10.4 ADAPTATION IN PRACTICE

10.4.1 Role of Institutions: From Field to National Level

Given the complexity and the diversity of climate change induced hazards and implications for lives and livelihoods of local communities, it is a mammoth task for the communities to face the challenges alone. Communities have devised their own mechanisms to cope with changes in climate throughout history, in a basic and limited way. The sheer scale and impact of climate change is enormous and coastal communities require external and institutional support, more than ever before. Government agencies and non-government actors can be supportive by complementing local initiatives, building on indigenous knowledge and culturally appropriate practices.

In order to remain closer to the field, institutions such as Water Management Organizations (WMOs), Social Forestry Groups (SFGs) and other Community Based Organizations are in a unique position to form the initial linkages with the upper tiers of the administration. These community-based organizations can interact with local government and state agencies. This requires strong policy making, followed by actions and legislation which only the national government can impose. In situations where the local government and community lack the essential resources to instigate adaptive change, local level NGOs have come forward to aid the development schemes.

During the planning and implementation of all the local level interventions, the local government has to be involved and sensitized. They are one of the most important stakeholders in the selection of beneficiaries, sites, as well as in the implementation of adaptation initiatives. Upazila and Union Parishad representatives need to be provided with basic knowledge on climate change and disasters, so that they are able to take informed decisions in their area. People in the coastal zone have reported that the Union Parishad plays a key role in disaster planning and management, especially in the case of cyclones. Similarly, government service providers such as the Department of Agricultural Extension (DAE) are also active in providing assistance to the local farmers and technology transfer, as observed in Noakhali.

In 2010, the Bangladesh Climate Change Trust (BCCT) Act was formulated and consequently the Government set up the Climate Change Trust Fund (CCTF) for implementing urgent and immediate actions of the Bangladesh Climate Change Strategy and Action Plan (BCCSAP). BCCSAP 2009 demonstrates the country's commitment and understanding of climate change and reflects national priorities in terms of adaptation and mitigation. Up to the fiscal year 2016-17, BCCTF received a total allocation of Tk. 3,100 crore to implement climate adaptation and mitigation projects in public and private sectors.

CCTF has been acclaimed for their investments in strengthening Local Government Institutions (LGIs) such as coastal municipalities in Bangladesh. A significant amount has been invested in projects like floating gardens in water-logged areas, supplying pure drinking water, enhancing sanitation facilities in flood prone areas, innovation and introduction of stress tolerant crops in coastal areas. CCTF prioritized projects with "co-benefits" like the Improved Cooking Stoves

(ICS) that promotes health, reduces air pollution and also empowers women. Innovative projects included community-based projects that used "revolving funds" for solar electrification and irrigation in coastal areas.

10.4.2 Education: Awareness and Communication

In the third phase of the Char Development and Settlement Project (CDSP III) an initiative was undertaken to raise awareness and educate the coastal children on issues of climate change. The approaches included art and essay competitions, children's books and teacher's guide on climate change, staging of a folk drama, documentary presentations and creation of a climate change curriculum. School visits and sessions with children, awareness programs for teachers, distribution of posters, stickers and calendars aimed at leaving a lasting image of the adaptation messages with the children and the community at large.

Inspired by the success of "entertainment education" of UNICEF's Meena (communications initiative), IUCN Bangladesh in partnership with CDSP III piloted a number of communication materials, using the mascot "Rana Bhai". Rana Bhai with his sunny disposition was an effective tool to raise awareness and increase communication among children on climate change adaptation issues. In addition to starring in his own play, Rana Bhai has been the centerpiece of numerous posters and stickers. Rana Bhai is an iconic character who radiates knowledge and wisdom. His very name Rana has been adopted from the scientific name for frog, Rana tigerina. As a Bangladeshi national, he has taken the appearance of a *shona bang*, the Bull Frog which is native to our country. Being a frog and an indicator species, the amphibious bright yellow Rana bhai is very susceptible to climate change. Children can also relate to him better because Rana is a common bangla name. The suffix "bhai", which literally means elder brother, was added to his name to establish a warm brotherly relationship with the children.

The Coastal Livelihoods Adaptation Project (CLAP) an initiative of GTZ (German Development Cooperation) partnered with IUCN Bangladesh to develop Information, Education and Communication (IEC) materials such as information books and guides for primary and secondary school students and their teachers in Bangla. This is an example of replication of the activities implemented by CDSP III; they were up-scaled to include information on coastal adaptation, cyclonic warning signals, plantation of tree species suitable for the coast, a disaster map of the country, etc. The project continued for a few years to experiment with effective communication tools to engage coastal communities, especially children.

According to a research conducted in Char Fassion and Kutubdia Island in Bangladesh, social networking has largely aided the communication between migrants from coastal areas. The use of mobile phone before, during and after a disaster exemplify "micro-coordination" during times of emergencies. According to the research, mobile phone technologies have been pivotal in maintaining social ties and facilitating mobility. Social networking has enabled information sharing via platforms. Research in Kutubdia revealed that school children are better able to communicate disaster warnings to their friends and family using Facebook. Information on disasters are now readily available to social media users, which include children living on remote islands.

The government realized that awareness at all levels of the society is absolutely essential for primary (such as coastal communities) as well as secondary (such as government institutions) stakeholders. It has been catalytic in incorporating climate change issues across all sectors in Bangladesh. Specific and appropriate awareness and training packages have been designed for schools, local government, local administration, policy makers, with special emphasis on women. Currently, online portals and printed materials are available, such as students' books on climate change. The Comprehensive Disaster Management project of the Department of Disaster Management issued board games and information bulletins have been disseminated across the vulnerable regions of the country.

Field level institutions such as WMOs and SFGs have been capacitated on issues of climate change, from different projects. This will bring long-term benefits as their roles are crucial as the conduit between communities and the local government, state agencies and further in the chain to knowledge-based organizations. Environmental committees at the Union Parishad level are functional in addressing climate change issues, but their roles and budgetary allocations need to be redefined. Research think-tanks such as the International Center for Climate Change and Development (ICCCAD) have been instrumental in disseminating climate change knowledge to government agencies and planners at various levels. It is worth mentioning that several state universities located in coastal districts such as the Patuakhali Science and Technology University, Khulna University and Chittagong University have introduced curriculum on climate change and disasters.

10.4.3 Disaster Resilient Structures

One of the worst effects of disasters and climate change are the direct losses incurred from damaged infrastructures such as coastal homes and fishing boats. In most cases, the extra cost for repair and reconstruction is beyond the reach of the impoverished communities. IUCN Bangladesh, with financial assistance from the Netherlands Climate Change Assistance Program (NCAP) carried out action research activities in southern coastal regions of Noakhali on building disaster resilient structures. These activities resulted in basic structural modifications for coastal homesteads and strengthening fishing boats that venture out to the sea. A total of six disaster resilient homes, two schools and six fishing boats were re-modeled, strengthened or modified after extensive consultations with community members, local masons and carpenters, and architects from the naval and architecture departments of BUET and BRAC University. The robustness of the improved disaster resilient homes was put to test during Cyclone Alia which hit the coastal zone in 2009; they were able to withstand a wind velocity of about 220 km/hour. Prototypes of the design of the disaster resilient homes was adopted by the CDSP project, as a successful model for up-scaling. The Pilot Program on Climate Resilience (PPCR) and UNDP Bangladesh have also implemented projects on disaster resilient homes in coastal and disaster-prone areas of Bangladesh in the recent past.

10.4.4 Climate Adaptive Agriculture

Agriculture is one of the main drivers of development in the coastal regions of Bangladesh (see Chapter 7). Manifestations of climate change such as salinity intrusion pose as one of the biggest threats to the livelihoods of the marginal farmers and share-croppers. IUCN Bangladesh worked on different aspects of agriculture, including but not limited to social and economic issues, alternative cropping patterns, impacts on livelihoods and biodiversity in the coastal areas. Demonstration plots were set up in Noakhali, to test the productivity of BR 47, a high yielding and salt tolerant variety of rice. The involvement of DAE staff and local people, especially in testing this new variety was ensured, so that such initiatives are sustainable and replicable. The National Agricultural Research System (NARS) in Bangladesh has been pro-active in researching and promoting "climate-smart" agricultural practices across the country. International specialized organizations such as IRRI and CIMMYT have been working with coastal farmers through training and extension activities to further develop alternative and climate-tolerant agricultural practices. There are a number of indigenous techniques that the farmers have devised on their own in coastal Bangladesh like mixed cropping, cultivation of various vegetables and spices on a single piece of land, cultivation of rice and fish together, early harvesting, and cultivation of cash crops like fruits and vegetables to reduce reliance on rice harvests.

People's vulnerability can be further reduced by bringing about new and alternative crops suitable for a particular area that is salinity– or drought-prone. Research on the soil suitability and cropping patterns in coastal areas have been done by the Soil Resource Development Institute (SRDI) and need to be expanded to different terrains. Areas that are exposed to the sea, for instance newly accreted chars and off-shore islands have much scope for adaptive agriculture. BRAC has taken various initiatives with regard to the introduction of stress-tolerant rice varieties, of cultivation of maize and sunflower in the drought and salinity prone areas, of indigenous fish species conservation and of integrated aquaculture-agriculture technologies (see Chapters 6 and 7). Also, several alternative adaptation practices are already in use by Bangladeshi farmers such as floating gardens or "hydroponics", multiple cropping, *sorjan* method, double transplanting, integrated homestead farming, etc.

10.4.5 Renewable Energy Access

The promotion of climate-smart agriculture is being done in coastal areas, with the use of solar irrigation and better agro-meteorological services and weather forecasting. The Bangladesh Meteorological Department (BMD) is implementing pilot-scale initiatives on using smart-technologies such as mobile messages on suitable weather and cropping patterns, for farmers in different ecosystems. Through a private-public partnership initiative, solar irrigation projects have been funded in climate vulnerable areas of Bangladesh. The CBA-ECA (Ecologically Critical Areas) project implemented by the Department of Environment (DoE) worked on creating resilient communities in coastal and *haor* areas. To familiarize use of renewable energy as a mitigation measure, the project installed solar irrigation pumps for farmers. Solar desalination plants were set up in coastal areas such as Cox's Bazar and Shah Porir Dweep in Teknaf to supply safe freshwater to the coastal communities at a low-cost. Improved Cooking Stove (ICS) and Solar Home Systems (SHS) were provided at household levels to reduce carbon emissions, dependency on fuelwood and curb indoor air pollution for improving the health of women. Ensuring access to renewable energy contributes both to adaptation and to the mitigation of climate change. In the private sector, start-up companies such as SOLShare are experimenting with innovative models of generating and sharing solar energy in rural communities.

10.4.6 Income Generating Activities

Adaptation is the process of adjustment to climate change and its effects. Economic stability and livelihood security determine a person's adaptive capacity, whether a person is able to cope with climate change. In rural Bangladesh, agriculture is the primary source of livelihoods for a majority of the people. This dependence on farming makes them more vulnerable to climatic shocks and stresses. Over the past decade, Alternative Income Generating Activities (AIGAs) have gained popularity amongst the Government, NGOs and development partners. An investigation of five large climate change adaptation projects in Bangladesh (2001-2017) has concluded that AIGAs lead to an increase in livelihood security and this in turn builds resilience. AIGAs have also empowered women and created sustainable solutions for the growth of non-farm industries. These activities can empower vulnerable communities and make them more resilient to the impacts of climate change and natural disasters, as sustainable social business models.

10.5 FORTIFYING PEOPLE'S RESILIENCE

In this concluding section, an effort is being made to re-emphasize the fact that people's resilience is at the heart of climate change adaptation. This chapter has attempted to recapitulate the observations and experiences of climate change adaptation initiatives in Bangladesh, especially in the coastal areas. The lessons learnt through the process of engaging communities in vulnerable and disaster-prone areas have definitely contributed to the economic progress and socio-cultural betterment of the country. Different projects have targeted social development, improved livelihoods, awareness creation, natural rehabilitation, biodiversity conservation, institutional strengthening, better governance and enhancing coping capacities. Adaptation efforts such as using schools as cyclone shelters during emergencies have brought communities closer and created strong social ties. Another example of a globally acclaimed disaster risk reduction initiative in Bangladesh is the network of coastal volunteers called Cyclone Preparedness Program (CPP) which has saved the lives of millions in crisis. Coastal afforestation projects and mangrove restoration is another success story (see Chapter 4); the coastal green belt has proven to protect coastal communities by weakening the speed of cyclonic winds during cyclone SIDR.

The coastal communities face a multitude of vulnerabilities that are exacerbated due to the impacts of climate change and climatic variability. People have already observed changes and anomalies in rainfall patterns, temperatures and extreme weather events. As a response, they have started adapting and modifying their lifestyles to cope with the changes. In order to facilitate their adaptation, more context specific support should continue in the region. Throughout history, the people of Bangladesh have shown courage and determination in fighting all odds and the wrath of nature. It is expected that alternative development interventions will fortify people's adaptation strategies and foster a future generation that is able to cope with the changes in climate.

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Chapter 11

Climate Change, Bangladesh and the Estuary

Zahir-ul Haque Khan and Md. Mahfuzur Rahman

11.1 INTRODUCTION

At many places in this book, climate change and its consequences have been discussed. Chapter 3 talked briefly about the consequences for infrastructure. Chapters 4 to 7 have indicated the effect of climate change on forestry, fisheries, livestock development and agriculture. Chapter 10 shows that people in the coastal areas have seen for themselves that changing weather patterns are occurring and that they have started to develop their own coping strategy. The aim of the current chapter is to provide information to the general reader on widely accepted trends (section 11.2), more specifically on what these trends mean for Bangladesh (11.3), and on the consequences of these foreseen developments for the coastal zone in general and for the estuary (11.4). The chapter closes with concluding remarks in section 11.5.

The impacts of climate change for Bangladesh are most critical because of its geographical location, high population density, high levels of poverty, and the reliance of many livelihoods on climate-sensitive sectors, such as agriculture and fisheries.

The anticipated effect of climate change on coastal polders and chars as far as water management is concerned, is overtopping of embankment, damage of drainage systems, water-logging, crop damage and decline of livelihood opportunities for farmers and fishers. Current water management practices and coastal infrastructure may not be robust enough to cope with the impacts of climate change. It demands improved incorporation of information about current climate variability and climate change into planning and design of water infrastructure. Increase of precipitation and sea level rise in the changing climate may cause prolonged drainage congestions in the proposed project area, if this driver is not included in designing the drainage systems.

Climate change is a serious threat to sustainable development. At the macro-level, the combined effects of climate change could range from a loss of 1.3% of GDP per year in a moderate climate change environment to 2.0% of GDP per year in an extreme climate change environment, as mentioned in the Bangladesh Delta Plan 2100 (see Chapter 12).

11.2 THE REPORTS OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

The world's climate has always varied naturally, but compelling evidence from around the world indicates that a new kind of climate change is now under way, foreshadowing drastic impacts on people, economies and ecosystems. Levels of carbon dioxide and other "greenhouse gases" in the atmosphere have risen steeply during the industrial era, owing to human activities like fossil fuel use and deforestation, spurred on by economic and population growth.

Scientific evidence of human interference with the climate first emerged in the international public arena in 1979 at the First World Climate Conference. As public awareness of environmental issues continued to increase in the 1980s, governments grew even more concerned about climatic issues. In 1988, the United Nations General Assembly adopted resolution 43/53, proposed by the Government of Malta, urging: "...protection of global climate for present and future generations of mankind." In the same year, the governing bodies of the World Meteorological Organization and of the United Nations Environment Program created a new body, the Intergovernmental Panel on Climate Change (IPCC), to marshal and assess scientific information on the subject. In 1990 the IPCC issued its First Assessment Report, which confirmed that the threat of climate change was real.

Since then, and especially in the last decade, significant progress has been made in the understanding of past and recent climate change processes, and in projecting future changes. The Fifth Assessment report of IPCC was published in 2013. For the Fifth Assessment Report of IPCC (AR 5), the scientific community has defined a set of four new scenarios, denoted Representative Concentration Pathways (RCPs). They are identified by their approximate total radiative forcing in year 2100 relative to 1750: 2.6 W m-2 for RCP2.6, 4.5 W m-2 for RCP4.5, 6.0 W m-2 for RCP6.0, and 8.5 W m-2 for RCP8.5. Table 11.1 provides an overview of these four scenarios, as presented by Vuuren et. Al in 2011. Figure 11.1 gives a historical trend and future projectons (sorce Meinshausen et al 2011).

Table 11.1 Main Characteristics of Each RCP

Scenario/ Component	RCP2.6	RCP4.5	RCP6	RCP8.5
Greenhouse gas emission	Very low	Medium low mitigation Very low baseline	Medium baseline high mitigation	High baseline
Agricultural area	Medium for cropland and pasture	Very low for both cropland and pasture	Medium for cropland but very low for pasture	Medium for both cropland and pasture
Air Pollution	Medium-low	Medium	Medium	Medium-high

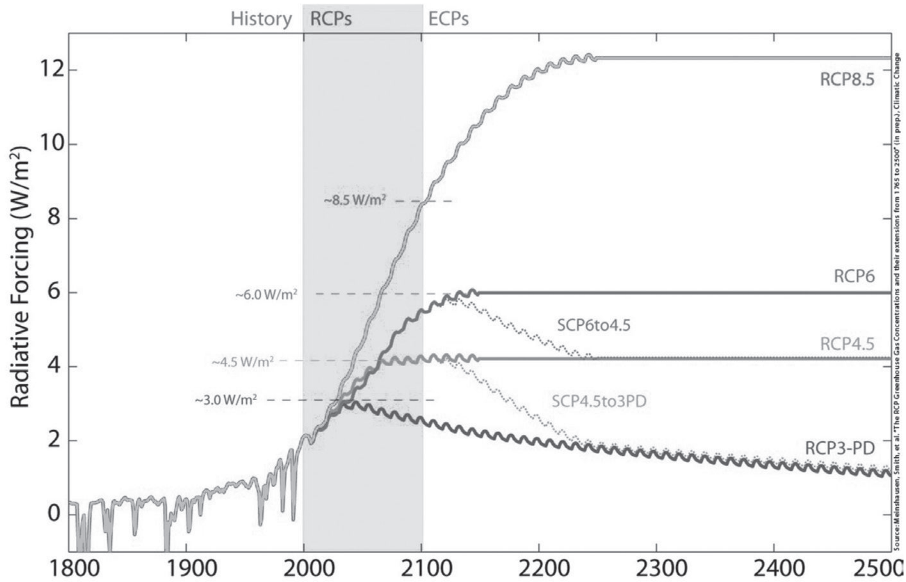

Figure 11.1: Global Anthropogenic Radiative Forcing for the High RCP8.5, the Medium-High RCP6, the Medium-Low RCP4.5 and the Low RCP3-PD

IPCC concluded that the evidence that climate change is already occurring is unequivocal and is due in large part to human activity. The global surface temperature change for the end of the 21st century is likely to exceed 1.5°C relative to 1850 to 1900 for all RCP scenarios, except RCP2.6. It is likely to exceed 2°C for RCP6.0 and RCP8.5, and more likely than not to exceed 2°C for RCP4.5. Warming will continue beyond 2100 under all RCP scenarios except RCP2.6. Warming will continue to exhibit interannual-to-decadal variability and will not be regionally uniform. The global ocean will continue to warm during the 21st century. Heat will penetrate from the surface to the deep ocean and affect ocean circulation.

Table 11.2 gives projections of temperature for South Asia based on the CMIP5 (Coupled Model Intercomparison Project) global models. CMIP5 defined a set of 35 climate model experiments useful in assessing the mechanisms for model differences in poorly understood feedbacks associated with the carbon cycle and with clouds, in examining climate "predictability" and in determining why similarly forced models produce a range of responses. The temperature responses are first averaged for each model over the 1986–2005 period from the historical simulations and in the projected periods of the RCP8.50 experiments as taken up in the IPCC working group 1 report, that contributed to AR5.

Table 11.2 Temperature Projections (at South Asia)

Scenario	Region	Month	Year	Min	25%	50%	75%	100%
RCP 8.5	South Asia	DJF	2035	0.3	0.8	1.0	1.2	1.6
			2065	1.5	2.2	2.6	3.0	3.7
			2100	3.5	4.1	4.6	5.7	7.1
		JJA	2035	0.3	2.0	2.0	1.0	1.3
			2065	1.2	1.7	2.0	2.3	3.3
			2100	1.3	3.0	3.7	4.6	5.6
		Annual	2035	0.4	0.8	0.9	1.0	1.4
			2065	1.5	2.0	2.2	2.6	3.1
			2100	3.1	3.7	4.1	5.2	6.0

Sea Level Rise

Global mean sea level will continue to rise during the 21st century. Under all RCP scenarios, the rate of sea level rise will very likely exceed that observed during 1971 to 2010 due to increased ocean warming and increased loss of mass from glaciers and ice sheets.

The primary contributions to changes in the volume of water in the ocean are the expansion of the ocean water as it warms and the transfer to the ocean of water currently stored on land, particularly from glaciers and ice sheets. Water impoundment in reservoirs and ground water depletion (and its subsequent runoff to the ocean) also affect sea level. Change in sea level relative to the land (relative sea level or relative mean sea level) can be significantly different from the global mean sea level (GMSL) change because of changes in the distribution of water in the ocean, vertical movement of the land and changes in the Earth's gravitational field.

These observations, together with our current scientific understanding and projections of future climate and sea level, imply that it is virtually certain that sea level will continue to rise during the 21st century and beyond. For the first few decades of the 21st century, regional sea level change will be dominated by climate variability superimposed on the climate change signal. For all scenarios, the rate of 21st century GMSL rise is very likely to exceed the average rate during the 20th century. For the RCP8.5 scenario, the projected rate of GMSL rise by the end of the 21st century will approach average rates experienced during the deglaciation of the earth after the Last Glacial Maximum. These rates imply a significant transfer of mass from the ice sheets to the oceans and associated regional departures of sea level rise from the global average, in addition to the regional patterns from changing atmosphere–ocean interactions. The projected rise in sea level under four scenarios in accordance with AR5 is illustrated in Table 11.3 and Figure 11.2.

Table 11.3 Projection on Global Mean Sea Level

Source	Region	Scenario	(2046-2065)		(2081-2100)	
			Mean	Likely ranged	Mean	Likely ranged
IPCC 5th Assessment Report, 2013	Global Mean Sea Level Rise (m)	RCP2.6	0.24	0.17 to 0.32	0.44	0.28 to 0.61
		RCP4.5	0.26	0.19 to 0.33	0.53	0.36 to 0.71
		RCP6.0	0.25	0.18 to 0.32	0.54	0.37 to 0.72
		RCP8.5	0.30	0.22 to 0.38	0.74	0.52 to 0.98

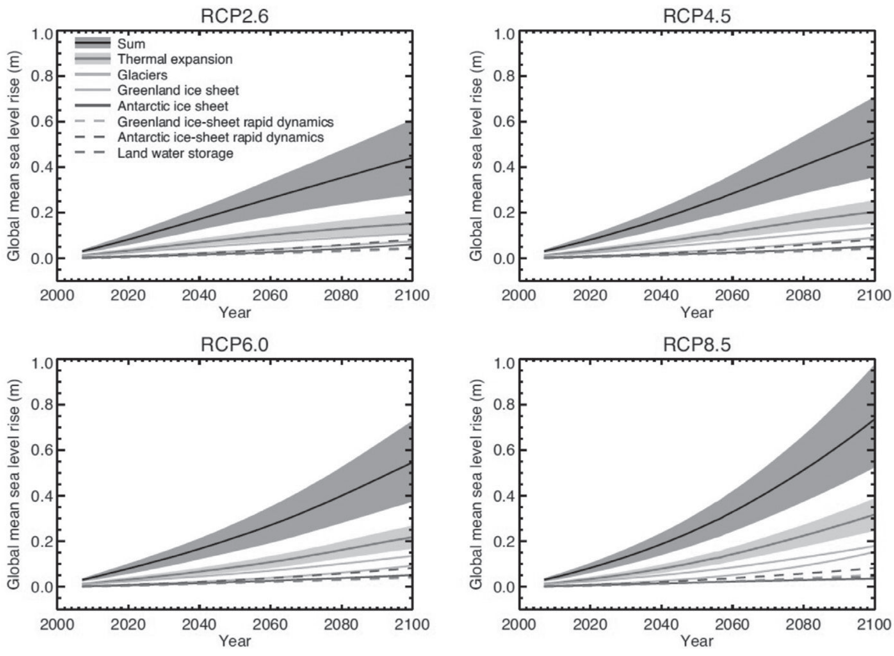

Figure 11.2: Projections from Process-Based Models of (a) Global Mean Sea Level (GMSL) Rise Relative to 1986–2005. For GMSL Rise and the Thermal Expansion Contribution, the Likely Range is Shown as a Shaded Band

IPCC also given projection on in the Bay of Bengal, which shown in the following figure. For the future, the IPCC projections for very high emissions (red, RCP8.5 scenario) and very low emissions (blue, RCP2.6 scenario) are shown (see Figure 11.3).

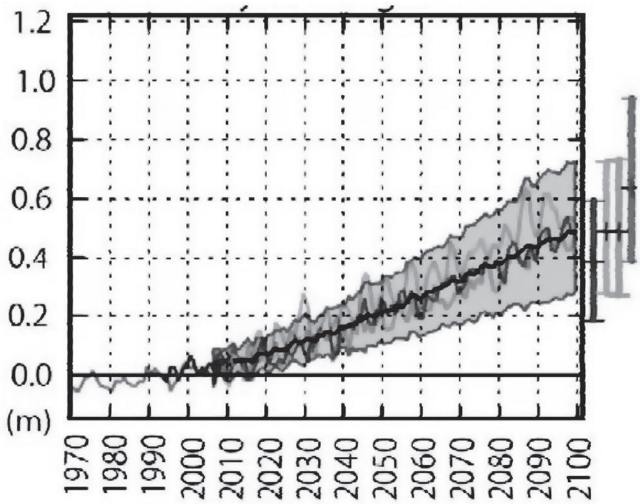

Figure 11.3: Sea Level Rise in the Bay of Bengal IPCC Projections (2013) for Very High– (RCP8.5) and Very Low Emissions (RCP2.6)

Table 11.4 Future Sea Level Rise Scenario for the Bay of Bengal (IPCC AR5)

Source	Region	Scenario	(2046-2065)		(2081-2100)	
			Mean	Likely ranged	Mean	Likely ranged
IPCC 5th Assessment Report, 2013	Bay of Bengal	RCP2.6			0.38	0.18 to 0.59
		RCP4.5			0.49	0.28 to 0.72
		RCP6.0	0.21	0.11 to 0.34	0.49	0.29 to 0.72
		RCP8.5			0.64	0.39 to 0.93

11.3 THE SCENARIO IN BANGLADESH

11.3.1 Future Climate Characteristics

Based on recent reports and documents, like a World Bank report of 2010 and the Bangladesh Climate Change Strategy and Action Plan of 2009, the main characteristics of the future climate scenario in Bangladesh are summarized as follows:

- A warmer and wetter climate by 2050, except for the post-monsoon dry season;
- An increase in rainfall during the monsoon, with a more erratic pattern;
- Increased flows in the Ganges, the Brahmaputra and the Meghna of up to 20% , driven by the higher precipitation in the overall catchment area;
- Increased yearly peak water levels in northern regions and decreased ones in the southern regions;

- Increased severity of cyclones;
- Higher frequency and intensity of droughts;
- Higher sea levels.

More attention to rainfall and temperature, cyclones and sea level rise is given in sections 11.3.2, 11.3.3 and 11.3.4 respectively.

11.3.2 Precipitation and Temperature

Historical Trends

Long-term historical trends in climate variables such as rainfall, temperature, evaporation and sunshine duration in Bangladesh, have been investigated by the Climate Change Cell under the Ministry of Environment and Forests (since 2018 the Ministry of Environment, Forest and Climate Change). The analysis of annual maximum- and 7-day moving average of maximum rainfall, shows a trend of increasing precipitation at Chittagong, Sylhet, Mymensingh and Bogra stations. These places are more or less located on the path of the south-westerly monsoon wind. It implies that the intensity of heavy rainfall may have increased along the main route of the monsoon wind. The analysis of temperature series indicates a trend of an increase in annual and seasonal mean temperatures in Bangladesh. The overall trend in mean annual temperature is found to be +0.1°C and +0.21°C per decade (equivalent to +1.03 and +2.14°C per century), for data for the period of 1948-2007 and of 1980-2007 respectively. The warming has been more rapid in recent decades.

Analysis of measured temperature (1948-2010) at 34 locations shows that the overall trend in all — Bangladesh annual temperature is rising at a rate of about 1.2°C per century. This trend has become stronger in recent years. The trend in recent mean annual temperature (1980-2010) is almost the double of the longer-term. Trend analysis of observed rainfall indicates that the annual rainfall in the country is free from significant changes and trend.

It is virtually certain that, in the long term, global precipitation will increase with increased global mean surface temperature. Global mean precipitation will increase at a rate per degree Celsius smaller than that of atmospheric water vapor. Changes in average precipitation in a warmer world will exhibit substantial spatial variation. Some regions will experience increases, other regions will experience decreases and yet others will not experience significant changes at all.

CMIP5 models on average project a gradual increase in global precipitation over the 21st century: change exceeds 0.05 mm/day (~2% of global precipitation) and 0.15 mm/day (~5% of global precipitation) by 2100 in RCP2.6 and RCP8.5, respectively. Figure 11.4 depicts change in average precipitation for 1986 to 2005 and a projection for 2081-2100, that can be found in a report of IPCC Working Group no. 1. IPCC has three Working Groups; no. 1 aims at assessing the physical scientific basis of the climate system and climate change.

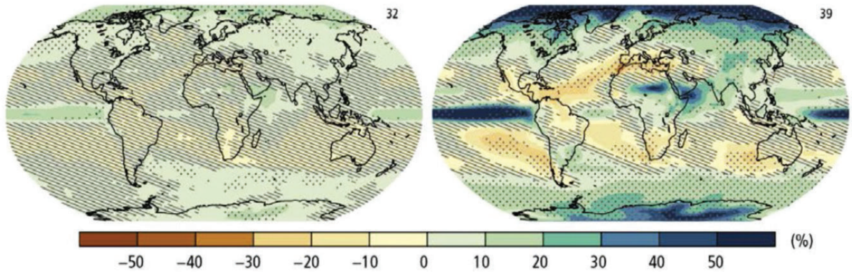

Figure 11.4: Change in Precipitation Based on Multi-Model Mean Projections for 2081–2100 Relative to 1986-2005 Under the RCP2.6 (left) and RCP8.5 (right) Scenarios. The Number of Models Used to Calculate the Multi-Model Mean is Indicated in the Upper Right Corner of Each Panel.

The general pattern of change indicates that high latitude land masses are likely to experience greater amounts of precipitation due to the increased specific humidity of the warmer troposphere as well as increased transport of water vapor from the tropics by the end of this century under the RCP8.5 scenario. Many mid-latitude and subtropical arid and semi-arid regions will likely experience less precipitation and many moist mid-latitude regions will likely experience more precipitation by the end of this century under the RCP8.5 scenario.

Table 11.5 shows the precipitation change projections for South Asia by the CMIP5 global models, as reported by IPCC Working Group no. 1. The precipitation responses are first averaged for each model over the 1986–2005 period from the historical simulations and in the projected periods of the RCP8.5 experiments.

Table 11.5 The Precipitation Change Projections for South Asia by the CMIP5 Global Models

Scenario	Region	Month	Year	Min	25%	50%	75%	100%
RCP 8.5	South Asia	DJF	2035	-13	-2	1	6	20
			2065	-16	-4	4	10	23
			2100	-17	-1	12	21	42
		JJA	2035	-3	1	3	5	16
			2065	-1	7	10	13	27
			2100	-9	13	17	23	57
		Annual	2035	-2	1	3	5	11
			2065	0	6	8	11	17
			2100	-7	11	18	21	45

Note: DJF: December-January-February, JJA: June-July-August.

11.3.3 Cyclones

A number of research studies has been performed on the projection of cyclonic wind speed in a changing climate. Predictions of cyclonic wind speed at global scale and in North Indian Ocean estimated by other researchers is given in the following table, derived from a report of IPCC Working Group no. 1.

Table 11.6 Tropical Cyclone Intensity Change Projections (percent Change in Maximum Wind Speed)

Reference	Technique/ Model	Resolution/Metric Type	Climate Change Scenario	Global (In percentage)	North Indian Ocean
(Vecchi and Soden, 2007)	Emanuel PI, reversible w/ diss. Heating	Max Wind speed (%)	CMIP3 18-model A1B (100-year trend)	2.6	4.4% ; (–3.3 ~ 16.0)%
(Murakami et al., 2013)	JMA/MRI global AGCM time slice	V3.1 20 km, V3.2 20 km; Avg. max winds over lifetime of all TCs	Downscale CMIP3 multi-model ens. A1B change (2075–2099 minus control)	(11~4)	(5 ~7)%
(Oouchi et al., 2006)	MRI/JMA Time slice	TL959 L60 (~20 km) Avg. lifetime max wind speed	10 year A1B 1982–1993 2080–2099	10.7	–12.8
(Emanuel et al., 2008)	Statistical/ Dynamic Model	Max Wind speed (%)	CMIP3 7-model A1B (2181–2200 minus 1981–2000)	1.7	0.2
(Knutson et al., 2001)	GFDL Hurricane Model	18 km grid w./ ocean coupling; Max Wind speed (%)	GFDL R30 downscale, +1% yr–1 CO2 yr 71–120 avg	6	
(Yu et al., 2010a)	Emanuel PI modified by vertical wind shear	Max Wind speed (%)	CMIP3 18 model ensemble 1% yr–1 CO2, 70-year trend		3.3

11.3.4 Sea Level Rise

Sea level rise along the coast of Bangladesh is not known specifically from observed data. There are some tide gauges along the coast of Bangladesh, maintained by BIWTA, Survey of Bangladesh (SOB) and Bangladesh Water Development Board. Efforts have been made to examine the trend of water level along the coast analyzing time series tide data of these stations. It is observed that annual mean water level trend is 2mm/yr in the Karnaphuli river. Following Figure 11.5 shows the trend of water level.

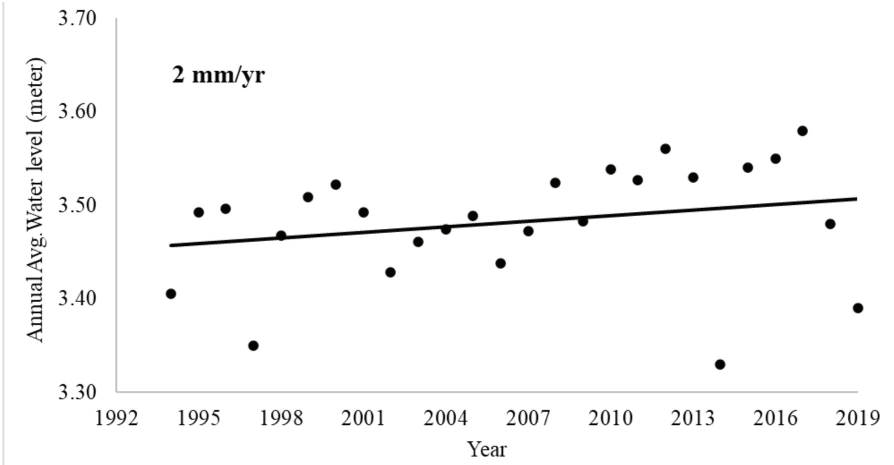

Figure 11.5: Trend of Water Level 1992-2019 at Rangadia in the Karnaphuli River

The annual trend of water level at Hironpoint in the Pussur river is 6.4mm/yr, which is high, it might be combination of subsidence and sea level rise. The trend analysis of water level in the Pussur river is presented in figure 11.6.

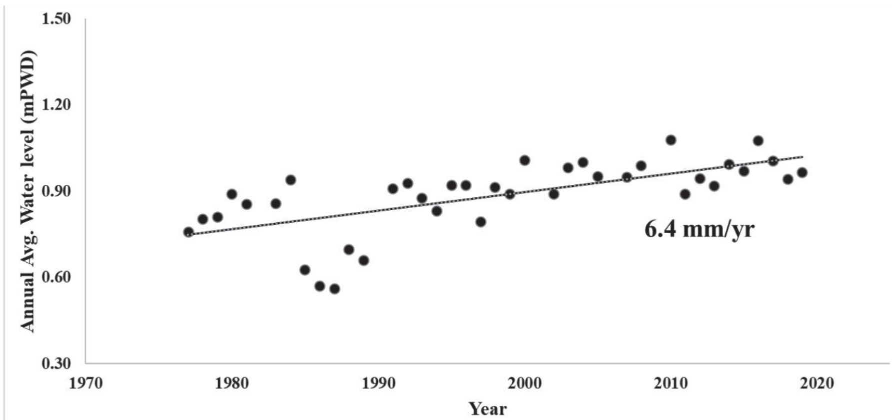

Figure 11.6: Trend of Water Level 1970-2020 at Hiran Point in the Pussur River

11.4 MAIN CONSEQUENCES FOR THE COASTAL ZONE AND THE ESTUARY

11.4.1 Water Logging

Bangladesh started a program in the early sixties, to develop polders through the construction of embankments to protect the low-lying coastal area against tidal and monsoon flooding and salinity intrusion. Currently, there are 139 polders having 5,017 km of embankments, of which 957 km enclose 49 sea-facing polders and the remaining 4,060 embankments enclose interior polders. These embankments protect around 1.2 million ha of land of which an estimated 0.8 million ha is cultivable land. Drainage is maintained by 1,347 regulators and 5,932 km of drainage channels. They protect the densely populated coastal areas of Bangladesh. Polders are currently not in place in areas that are less populated and where there is limited economic activity, including the Sundarbans and a number of small islands in the Bay of Bengal. A number of polders in the districts of Jessore, Khulna, Satkhira and Bagerhat has been experiencing drainage congestions due to deterioration in the peripheral rivers. The deterioration is caused by increased siltation due to the reduction in fresh-water flow through the Ganges system. As a result of the ever extending length of the drainage path, drainage congestions also occur in coastal areas of Lakshmipur, Noakhali and Feni.

Sea level rise, in combination with an increase of precipitation, is likely to cause severe water-logging in the coastal polders. The land surface also undergoes downward changes in elevation, due to subsidence. This subsidence is in polders not compensated by sediment depositions, because tidal floods cannot enter the area. Obviously, the subsidence will worsen the drainage condition, on top of the impact of sea level rise. A total of 59 polders are likely to experience severe drainage congestion with an increase of 27 cm sea level rise and with 20 to 25 % increase of precipitation. The majority of these polders are in the southwest region and only a handful are located in the central part of the coast. It is estimated that a total number of 1,475 additional vents (gates of sluices) are required to avoid additional drainage problems. Just improving the internal drainage will not be sufficient, however, since water levels in the outfall rivers would remain high, impeding natural, gravity induced drainage. In such cases, pumping may be required to mitigate the situation.

Since 1998, experience was gained in the southwest region of the coastal zone with Tidal River Management. This method allows natural tidal movement in an embanked low-lying area (tidal basin) and enables deposition of incoming sediment during high tide inside the tidal basin. During low tide, the riverbed is eroded, thereby increasing the drainage capacity. This is confirmed by monitoring results. It is a nature based no regret measure for solving water-logging problems. The method is technically and economically feasible, environmentally friendly. However, it has social and institutional challenges for obtaining land for TRM basin and giving compensation to landowners for operating TRM in their land.

11.4.2 Storm Surge Induced Inundation

Cyclonic storms affecting the coastal region of Bangladesh cause heavy loss to life and property. The coastal region bordering the Bay of Bengal suffers the worst, because most of the tropical cyclones have their origin over the Bay and then strike the coast of Bangladesh. The vulnerability of the coastal area to storm surge flooding is high, since it is a predominantly low-lying area, with numerous tidal rivers. Due to the increase of population and investments in coastal Districts, the urgency of being prepared for disasters and consequently of having quantitative estimates, have increased in recent years. Bangladesh has been identified as the most vulnerable country in the world to tropical cyclones. During the pre-monsoon (April to May) and post monsoon (October to December) periods, disastrous tropical cyclones form in the Bay of Bengal. Most of the cyclones hit the coasts of Bangladesh with a north-eastward approaching angle.

In the period 1960-2009, 19 severe cyclones hit the coast of Bangladesh. SIDR cyclone hit the Baleswar river coast on 15 November 2007, causing severe damage to infrastructure and loss of human lives. Cyclone SIDR alone resulted in damages and losses of $1.7 billion, or 2.6% of GDP in 2007. Cyclone AILA hit the southwestern coastal area of Bangladesh on 25 May 2009, damaging infrastructure in the Districts of Satkhira and Khulna. Cyclone Amphan hit southwest coast of Bangladesh on 20th May 2020. It is of immense importance to understand the expected impact of climate change on exposure of coastal infrastructure to storm surge induced inundation, in order to devise a climate resilient development plan.

The inundation risk exposure for the climate change scenario is developed from simulation results of cyclones, covering the whole coastline of Bangladesh, taking the following three assumptions into account: a rise in sea level of 27 cm (by 2050); increase in wind speed by 10% relative to cyclone SIDR; landfall occurs during high tide. The analysis shows that the inundation risk exposure is indeed considerable. In the baseline scenario, inundation depth is greater than 1 meter in 20,876 km2 of land, and greater than 3 meters in 10,163 km2. In the climate change scenario, the inundation depth increases for areas already inundated in the baseline scenario. In addition, areas further inland become inundated. The net result is an increase of 14% in the areas inundated by more than 1 meter and an increase of 69% in the areas inundated by more than 3m. The impact on agricultural crops is substantial. In 2050, 43% more of the *boro* crop would be exposed to inundation, 18% of the *aus* crop and 19% of the *aman* crop.

Table 11.7 shows that the combined effects of population growth and climate change nearly doubles the population exposed to inundation risk of more than 1 meter. The number of those at risk of inundation of more than 3 meters, will be increased two-and-a half times by 2050.

Table 11.7 Population Exposed to Inundation Risk (million)

Inundation Risk Exposure (Depth)	Baseline Scenario 2007 (a)	Baseline Scenario 2050 (b)	Percent Change between (a) and (b)	Climate Change Scenario 2050 (c)	Percent Change between (b) and (c)
More than 1 m	18.5	28.3	+ 53%	35.3	+25%
More than 3 m	8.9	13.5	+53%	22.6	+67%

11.4.3 Salinity Intrusion

Saline water intrusion is seasonal in Bangladesh. During the dry season, deep landwards intrusion occurs through the various tidal rivers in the western part of the delta, and through the Lower Meghna estuary. Sea level rise will bring more saline water in the river systems of the coastal area, which will eventually increase the extent of salt-water intrusion. The sea level rise, in combination with low upland flow during the dry season, will change the present spatial and temporal variation of salinity and the brackish water zone, which eventually would cause damage to irrigation, agriculture, fisheries and to the total eco-system of the coastal area. The Institute of Water Modelling (IWM) maintains water flow and salinity models for the Bay of Bengal and the coastal region of Bangladesh. Using the available water and salinity models, the impact of different values of sea level rise on salinity intrusion in the coastal area of Bangladesh was assessed.

IWM comes to the conclusion that the only fresh-water pocket used for agriculture in the Tetulia river becomes saline with a sea level rise of 88 cm. The 5 ppt isohaline (line with the same levels of salinity) intrudes 9 km landwards with a 32 cm rise of sea level, and about 90 km with a sea level rise of 88 cm. The Sundarbans, a world heritage site, which is already experiencing high salinity, will be affected more by salinity water intrusion due to increased sea level, both in the dry and the monsoon season. There are three zones in the Sundarbans, depending on salinity level: low, medium and high salinity zone. The low salinity zone becomes a medium salinity zone and the medium salinity zone becomes a high salinity zone. This change will affect the growth of wood and the bio-diversity of the Sundarbans. Salinity intrusion would cause significant changes in the fresh water and brackish water zones in the coastal area. With a sea level rise of 60 cm, an additional area of 327,700 ha becomes a high saline water zone (>5 ppt) during the dry season. In the monsoon, about 6% of the sweet water area (276,700 ha) will be lost. In the base condition (2005), about 6.0 million people are already exposed to high salinity (>5 ppt). This is expected to increase to 13.6 million in the year 2050 and 14.8 million in 2080 The population in Khulna, Satkhira and Bagerhat is likely to be exposed more than in other districts. Coastal islands in the estuary such as Nijhum Dwip, Hatiya, Sandwip, Urir Char and the southwest coast of Noakhali mainland are likely to be exposed to even higher salinity levels.

11.4.4 Sedimentation

The Ganges, the Brahmaputra and the Meghna rivers continue to supply about 1.1 to 1.4 billion tons of sediment to one of the largest deltas in the world, keeping the expansion of the delta in progress. Chapter 2 has given ample information on the processes leading to land accretion and erosion. We have seen that the major part of the enormous sediment load that reaches the estuary, is washed away to the deeper part of the Bay of Bengal. Only a part of the huge amount of sediment settles in the low-lying areas, close the coastline. It is expected that the increased flow will eventually lead to a higher supply of sediment to the Meghna Estuary. The sea level rise will increase the tidal prism. That may bring more sediment by tidal pumping into the Meghna Estuary as well. This will likely result in an acceleration of the land formation process. However, at the same time, the amount of land lost to erosion will probably be higher, also because of the higher river flows in the Ganges-Brahmaputra-Meghna river system. Based on past experiences, one can cautiously foresee that accretion will outpace erosion to a greater extent than until now was the case.

Two other phenomena in the estuary are of importance for its future shape: subsidence and sea level rise. It is considered that the maximum sea level rise along the coast of Bangladesh is about 5 to 6 mm per year. The subsidence rate is considered about 4 to 6 mm. The combined effect of sea level rise and subsidence is therefore about 10 to 12 mm per year. The average current sedimentation rate is estimated to be 20 to 30 mm. Given the uncertainties about future trends and developments, the general conclusion cannot simply be that sedimentation will outpace sea level rise and subsidence. The present pace of sedimentation may or may not compensate their combined effect. There will probably be local variations. In the near future, sediment deposition may compensate the combined effect of sea level rise and subsidence at certain places, like Jahazer Char, Urir Char, the south-eastern coast of Noakhali mainland, and the areas around Nijhum Dwip and Damar Char. The northeast coast of Bhola and North of Hatiya Island are likely to experience higher rates of erosion because of the increase of the tidal prism due to climate change, and will become more vulnerable to effects of higher sea levels and subsidence.

11.5 CONCLUDING REMARKS

In this section, a number of conclusions are supported that already have been reflected in other chapters.

Infrastructure

The probability of more water logging problems and of storm surge induced inundation points to the need of reviewing the status of the present infrastructure. To increase the drainage capacity, additional sluice gates have to be installed and the design criteria for new sluices have to be revisited. The crest level of embankments will have to be heightened in order to cope with the impact of storm surges and of the combined effect of sea level rise and subsidence. Design criteria for embankments should be reviewed.

Monitoring

It is essential that the current understanding of the processes taking place in the Meghna Estuary is updated on a permanent basis, including the impact of climate change on estuarine processes. More knowledge should be generated about the effects on matters like land formation, erosion and protection of coastal areas. Sediment transport and distribution, land accretion, erosion, tide and salinity are elements to be included in the proposed permanent program. Such programs should be embedded in an effective institutional environment.

Mangrove Plantation

With a view on the properties of mangroves, they seem to be an ideal tree in the light of the anticipated effects of climate change, such as rougher seas, storm surges and salinity intrusion. In addition to the strengthening of the coastal infrastructure, especially the water management related structures, a study to identify the feasibility of additional mangrove plantations is indeed warranted.

Need for Adaptation

The particular needs of Bangladesh in adapting to climate change are of critical importance. In many key-ways, the problem of climate change is interlinked with development: economic growth is essential for the country to improve the livelihoods and quality of life of its citizen. Economic growth is also essential to increase the capacity of the country to adapt to the negative consequences of climate change. Adaptation at macro-level has to go hand-in-hand with adaptation at micro-level. Coastal communities have to be aware of future changes and their own, home grown coping strategies have to be supported.

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Chapter 12

The Bangladesh Delta Plan 2100

Dr. Jaap M. de Heer

12.1 THE BANGLADESH DELTA CHALLENGE

Bangladesh is the fifth most vulnerable country in the world in terms of risks from natural hazards and climate change. Climate change factors have substantial adverse effects on many key economic sectors in Bangladesh, adding up to potential significant economy-wide losses. The IPCC (2013) expects a sea level rise between 0.2 to 1m for low to high emission scenarios in 2100 for the Bay of Bengal. This will contribute to increased waterlogging, security risks in relation to floods, health and endangered livelihoods of the vulnerable population. Loss of land and climate change induced migration may be the direct result. At the macro-level, the combined effects of climate change, natural hazards and delta issues could range from a loss of 1-1.3% of GDP per year in a moderate climate change environment and from 2-2.5% of GDP per year in an extreme climate environment. Against this background, the Government of Bangladesh (GoB) considered to take comprehensive action to address vulnerability of the country with respect to natural hazards and climate change. This initiative was supported by the positive socio-economic development in Bangladesh with an average growth rate of 6% or even more. Bangladesh aspires to be a prosperous nation, reaching upper middle-income status and eliminate extreme poverty by Financial Year 2031. However, substantial downside risks from the interplay of its deltaic geographical configuration in relation to climate change, high population density, and regular episodes of a range of natural disasters, threaten the achievement of the mentioned aspirations.

Government's interpretation is that evidence from global experience as well as experience from Bangladesh itself indicate that climate change is a real threat to global and national level prosperity and that adaptation is required. Unless vulnerabilities as storm surges and flooding, sea level rise, salinity intrusion, water-logging, ground water depletion and coastal and river bank erosion are managed and addressed comprehensively, Bangladesh faces serious risks to food security, sustained economic growth and poverty reduction efforts. The most vulnerable sector is agriculture. Climate change, especially in areas of high temperature, humidity and radiation, increases the incidence of insect pests, diseases, and harmful micro-organisms. Minimum temperatures in Bangladesh are expected to increase between 2 and 5°C depending on the time period and emission scenarios. Rising temperature reduces yields of high-yielding varieties of rice. Farm productivity will fall from increase in soil salinity caused by sea level rise (SLR). Agriculture will suffer additionally from the higher incidence of climate change induced extreme precipitation and flooding, including inundation caused by SLR. The other most vulnerable sectors are forestry and ecosystems. Many of the anticipated adverse effects of climate change, such as SLR, higher temperatures, and an increase in cyclone intensity, will damage the forest resources of the country, put pressure on many climate-sensitive species, and cause increased erosion and deterioration of soil quality in many upland forested areas. The world's largest mangrove forest, the Sundarbans, is extremely vulnerable to climate change. SLR will increase saltwater intrusion and will negatively affect the forests or may even destroy them by highly increased saltwater levels.

Additional adverse effects will happen due to loss of land and physical assets from inundation. At 1 meter SLR a significant part of dryland in Bangladesh will be permanently inundated; the fall of production in all sectors in the economy due to loss of land quantity could lead to a substantial fall in real GDP. Climate change and resulting floods and cyclones will have a significant negative impact on capital stock in construction and infrastructure in Bangladesh. Health hazards will also intensify. Water-borne diseases, such as diarrhea and dysentery, and vector-borne diseases, such as malaria and dengue, are climate sensitive. Research suggests that growing morbidity could occur from dengue and malaria. In terms of loss of human welfare, district and sub-district level analysis shows that there is a strong positive correlation between incidence of poverty and the intensity of natural hazards. On average districts that are ranked as most exposed to natural disasters also show poverty rates that are higher than the national average.

In view of the special long-term challenges for development outcomes presented by climate change and natural hazards, the Government has decided to formulate a long-term Bangladesh Delta Plan 2100 (BDP2100). The BDP2100 seeks to integrate the short-to medium term aspirations of Bangladesh to achieve upper middle-income status and eliminate extreme poverty by FY2031 with the longer-term challenge of sustainable management of water, ecology, environment and land resources in the context of their interaction with natural disasters and climate change.

12.2 MANAGING UNCERTAINTIES AND LINKING SHORT-TO-MEDIUM TERM TO LONG TERM OUTCOMES

12.2.1 The Adaptive Delta Management Approach

The formulation of BDP2100 and its implementation are based on a long term and holistic strategic planning approach, being applied to a complex delta with many developments (and their drivers), associated uncertainties and implementation over time. The applied approach is called Adaptive Delta Management (ADM). ADM basically means managing uncertainty and risks strategically according to a long-term perspective, being prepared to some extent to immediate threats, able to adapt as and when required and when better solutions are available. The experience suggests that many traditional processes of planning, design and execution as well as of operations and maintenance show limited flexibility or that adjustments are even beyond the direct control of the appropriate institutions. In this respect, BDP2100 requires changing of the usual planning and decisions making process, impacting the delta and related governance and institutional environment.

The formulation of BDP2100 is a unique example of ADM showing a long-term orientation with adaptive strategy making and short-term actions. At the basis of the plan are a set of Baseline Studies showing conditions and challenges as well as the formulation of a Delta Vision. It is vital to the BDP2100 that issues that matter in achieving the BDP2100 long-term Vision are mainstreamed into appropriate institutions and political and economic processes and decisions.

12.2.2 Principles of Adaptive Delta Management

Adaptive Delta Management can be understood as a cyclic process in which the overall design does not differ much from traditional strategic planning steps. However, the approach of ADM and its methods contain new elements or building blocks for ADM, such as shown in Table 12.1.

Table 12.1 Principles of Adaptive Delta Management (ADM)

Principles of Adaptive Delta Management (ADM)
1. Holistic Delta Analysis of issues, challenges, knowledge gaps, with awareness of need for multi-sectoral planning
2. Accept Uncertainty, focus on main extemal trends/drivers, uncertainties and impacts
3. Significance of Future Conditions: consider scenarios as narratives of possible futures
4. Short Term Action/Investments to be flexible, adaptively connected with Long Term Vision and Goals, anticipating possible filture changes
5. Elaborate alternative Adaptation Pathways check for Tipping Points to act upon
6. Institutional Framework is key; institutionalization and mainstreaming of ADMoutcomes, coordination, implementation programmmg, monitormg and evaluation
7. Decision Support on strategies, investments and updating requires knowledge management and adequate data/information systems
8. Synergy with Stakeholders, connecting with other public (e.g., aging infrastructure, urban development, nature, shipping, recreation) and private investment ambitions
9. Investment Planning is needed, requires early indication of funding commitment
10. Avoid Over- and Under Investment by adaptive programmmg and adaptive design

The building blocks are applied as follows.

Holistically Analyzing Issues, Challenges and Knowledge Gaps in Relation to Multisectoral Planning

The Bangladesh Delta is a highly complicated and dynamic delta. Only a combination of dedicated disciplines, with a large number of themes to be studied, can successfully explore the mechanisms and highlight the real issues and challenges in a proper way. Holistic understanding and a multi-sectoral approach with involvement of the stakeholders are needed to address the challenges in the right way and to build ownership. Alignment with other processes to generate coherence and synergy is a must, as with realization of the SDG's.

Accepting Uncertainty and Consider the Main External Influences

Due to the uncertainties with respect to climate change and socio-economic development over the long term, the linear planning approach, which has been used for a long time, is being enriched with adaptive strategy making and adaptive design and implementation. Rather than business as usual approaches with short term action or stand-alone intervention, external influences need to be considered and flexible strategies and programs with consistent measures are needed. Strong institutions and a good knowledge infrastructure are also required to allow policy makers and stakeholders to anticipate and decide on the most appropriate investments. External scenarios play a role in understanding how the future may look like and how the vision and goals can best be achieved under various conditions and adaptive strategies.

Exploring the Significance of Future Conditions

A broadly accepted approach to exploring future conditions is the formulation of external scenarios, interpreted as narratives of possible futures. These are scenarios based on the evolution of external drivers and developments, such as climate change, population growth, economic development, modernization, industrialization and urbanization. They are called external drivers and developments because they can hardly be influenced. The drivers with the largest impact and uncertainties play a dominant role in scenario writing and use of data behind the narratives. Draft strategies have to be tested on robustness with respect to their performance under each scenario.

Connecting Short-Term Action and Investments with Long Term Vision and Higher Level Policies

As part of ADM, a strategist should create a strategic vision of the future, commit to short-term actions and establish a framework to guide future actions. Typical in ADM is that such a vision has a longer time horizon than usual in planning activities (e.g., 100 years), to capture the effect of long-term processes and trends, such as climate change. So instead of focusing on short-term "trial and error" actions and projects, the idea is to keep the long-term vision in mind while prioritizing short-term "no regret" actions.

Elaborating Path Dependency, Adaptation Pathways and Tipping Points

The history of deltas shows developments which, once started, cannot easily be changed or adapted to new conditions. This is what is called path dependency: the extent to which a policy action is limited by actions implemented in the past or by actions planned to follow anterior in the future. Learning from the past and recognizing that we cannot predict the future leads us to the ambition to avoid such lock-ins. One way to do this is to explore adaptation pathways, i.e., the flexible sequencing of different policy actions over time to achieve a given set of objectives. Definition of signposts or triggers is useful to signal in time that certain measures are (for whatever reasons) no longer effective to achieving the vision and goals and a switch to other measures in the pathway may be needed.

Developing Institutional Framework for Mainstreaming BDP2100, Coordination and M&E

ADM will, given its long-term vision and goals, multi-sectoral planning and impact as well as large investments, be closely related to the core governance of the country. Mainstreaming of BDP2100 in the Five Year Planning Cycle and a close relation with the upcoming Perspective Plan 2041 is of crucial importance for effective implementation and consistency over time. A clear institutional framework is required to achieve that, as well as to facilitate decision making, funding, multisectoral planning and implementation and to provide room for dedicated people's participation. Moreover, "Delta Management" is not another connotation of "Water Management" because Delta Management goes further. Delta Management, as is obvious from the BDP2100 as "water centric techno-economic long term holistic and multi sectoral plan", relates to water safety and security, facilitates food security and economic growth and contributes to national level goals promoting prosperous development of the nation.

Decision Support

Utilization of data and decision support models for preparation of project proposals and for selection or prioritization of projects or other measures are needed.

Synergy with Stakeholders: Connecting Public and Private (Investment) Agendas

Another building block for ADM is to actively search for windows of opportunity to combine different investment agendas, either within the public domain or between public and private investments. This way, measures may be easier (and cheaper) to implement and yield more added (societal) value.

Investment Planning

It is important that already in the strategic planning phase the possible investments over the short term and the various ways to finance the investments are elaborated. Financing needs to be considered as it can be done, e.g., with government budget, funds generated from cost recovery or taxation, support of development partners or International Financial Institutions or Funds as the Green Climate Fund.

Avoiding Over– and Under-Investments

Insight from adaptation pathways is not only relevant for maintaining flexibility in adaptive plans, but also to limit the risks of over– or under– as well as too early– or too late-investments. Underinvestment occurs if it turns out that the solutions are not adequate and may lead to calamitous outcomes. Overinvestment on the other hand happens when measures are over dimensioned or ultimately unnecessary, which can prove costly.

12.2.3 Phases in Applying Adaptive Delta Management

There are five phases in applying ADM which have been followed under BDP2100. The first phase focuses on identification of characteristics of the various systems and on the current and future problems and challenges based on relevant future scenarios. In the second phase, vision, mission and goals are defined and options to address the gaps and challenges are explored to enhance the sustainability and/or reduce the vulnerability for both current threats and longer-term uncertain futures. The third phase focuses on integrating the adaptation options into viable management strategies and ensuring their robustness against the plausible set of scenario outcomes. The elaboration of measures and projects belonging to the strategies also takes place in this phase, including the preparation of monitoring and investment plans to specify appropriate signals, triggers and financing mechanisms. In the fourth phase, the approval process contains extensive consultation, reflection and improvements of the strategies and overall plan, with final high-level approval and endorsement. In the fifth phase, proper implementation is prepared, aiming at the realization of the approved plan including fund generation and allocation.

The practical implications of ADM during implementation of BDP2100 play a meaningful role in the following actions:

- Managing institutional developments and activities to enable strategy operationalization and implementation;
- Capacity building and learning what adaptation means and requires regarding implementation;

- Monitoring of the main drivers of change (as climate change, transboundary issues, economic development), assessing uncertainties (gaps, unknowns) and looking for approaching tipping points;
- Adaptive designing of proposed projects in accordance with the mentioned principles;
- Seeking adaptation pathways with optimal and state of the art solutions;
- Implementing any enabling actions to ensure future long-term options remain open;
- Managing knowledge and data according to implementation needs;
- Mainstreaming BDP2100 input in the Five Year Planning Cycle;
- Result based monitoring and evaluating results in light of vision, mission, goals and strategies.

Most of these aspects have been prepared in general terms during the BDP2100 formulation stage and are further developed in the implementation stage on the basis of five major implementation capacities (see section 12.7).

12.3 AMBITIONS, VISION, MISSION AND GOALS

12.3.1 Considerations in the Initial Phase

After taking the initiative by the Government of Bangladesh to address the delta related issues and challenges, a Memorandum of Understanding was signed in 2012 with the Dutch government given its experience with the Dutch Delta Plan and Program, providing a basis for collaboration between the two countries to develop BDP2100. Under this MoU, the "BDP2100 Formulation Project" was fielded in 2014-2018, followed by the "Support to Implementation of BDP2100" (SIBDP) in 2018, which will be operational up to 2022. The BDP2100 and SIBDP are both hosted by the Ministry of Planning, under the General Economics Division (GED) of the Planning Commission. This choice was made considering (i) the mandate and experience within this Ministry with long term planning, e.g., of Perspective Plans 2021and 2041 as well as the Five Year Plans and coordination of the Sustainable Development Goals and (ii) the aim of GoB to follow a comprehensive planning process in a multi-sectoral way. Many sectors of society would be impacted by the above described climate change and natural hazards, reason why the GoB talked about multi-sectoral delta management instead of the usual sectoral water resources management.

So right from the beginning the scope of the BDP2100 Formulation Project was comprehensive and because of that, a holistic approach was needed to address the many interrelated factors and actors shaping the delta as it happens. The BDP2100 is therefor based on extensive baseline studies related to its holistic approach of water safety and security, food security and economic growth. In this way, BDP2100 seeks to understand the dynamics in the Bangladesh delta and to integrate these in short-to-medium term aspirations and strategies. GoB wants to achieve upper middle-income status and eliminate extreme poverty by 2031 supported by BDP2100 investments, while through BDP2100, addressing the longer-term challenges of sustainable management of water, ecology, environment and land resources in the context of natural disasters and climate change. By adopting an adaptive approach to its delta and climate change challenges, Bangladesh tries to avoid economic setbacks and wants to be flexible, step by step adapting to the expected situation, avoiding under– and over-investment and aiming at sustainable growth.

12.3.2 The Delta Vision and Mission

In relation to this and based on the baseline studies, a long-term Delta Vision and Mission were formulated to indicate strategic direction. To achieve this Vision and realize the Mission, BDP2100 aligns three higher-level national goals set by national plans with six specific Delta Goals that contribute to these higher-level goals. The Delta Goals focus in a pragmatic way on water, ecology, governance, land and related functions by providing short to medium-term measures (2030-50). BDP2100 is thus not planning for the entire period up to 2100 but recognizes that decisions taken today have implications for the longer-term agenda for 2050 and beyond. In this regard, it sets up a long-term vision and agenda for the development of the Bangladesh Delta by the end of the 21st century, and defines short and medium-term goals and strategies as steps to reach that Vision. Because of this approach, these goals, associated strategies, institutions and investments are moving targets and adaptive in nature. They are adaptive to changing natural events, e.g., climate change in order to respond appropriately and stay on course to achieve the long-term Delta Vision and Mission.

12.3.3 The Delta Goals

To achieve this Vision and realize the Mission, BDP2100 indicates three higher-level national goals set by national plans and six Delta Goals focusing on water, ecology and land use functions that contribute to these higher-level goals (see Table 12.2). The Bangladesh Delta Plan adopts herewith a broad multi-sectoral scope, and although inspired by the Dutch Delta Program, takes a different turn, also in the way the Investment Plan has been added in conformity with the broad scope.

12.3.4 Flexible and Long-Term Adaptive Approach: From Desired Future Situation to Strategies and Pathways

The mentioned uncertainties of climate change and its impacts as well as of the dynamics of natural resources and of the socio-economic system, make it imperative

Table 12.2 BDP2100 Vision, Mission and Goals

<table>
<tr><td colspan="6">LONG TERM BDP2100 VISION
Achieving a safe, climate resilient and prosperous delta</td></tr>
<tr><td colspan="6">BDP2100 MISSION
Ensure long term water and food security, economic growth and environmental sustainability while effectively reducing vulnerability to natural disasters and building resilience to climate change and other delta challenges through robust, adaptive and integrated strategies, and equitable water governance</td></tr>
<tr><td colspan="2">Higher Level Goal 1
Eliminate extreme poverty by 2030</td><td colspan="2">Higher Level Goal 2
Achieve upper middle-income status by 2030</td><td colspan="2">Higher Level Goal 3
Being a prosperous country beyond 2041</td></tr>
<tr><td>Delta Goal 1
Ensure safety from floods and climate change related disasters</td><td>Delta Goal 2
Enhance water security and efficiency of water usages</td><td>Delta Goal 3
Ensure sustainable and integrated river systems and estuaries management</td><td>Delta Goal 4
Conserve and preserve wetlands and ecosystems and promote their wise use</td><td>Delta Goal 5
Develop effective institutions and equitable govemance for in-country and transboundary water resources management</td><td>Delta Goal 6
Achieve optimal and integrated use of land and water resources</td></tr>
</table>

to adopt a flexible and long term adaptive approach where various scenarios need to be constructed and considered as narratives of possible futures. A preferred future situation of the Delta has been discussed and described in a guiding vision and mission statement as shown in Table 12.2, which can be back-casted to the present situation. Then it becomes clear which goals need to be formulated and which strategies or strategic pathways with measures, projects and actions will lead to the preferred situation. To elaborate all this, BDP2100 uses the best available information from its 26 Baseline Studies, analysis of other relevant existing documents and some additional research. Formulation of adaptive strategies started with preparing an overview of issues and challenges and many possible strategies and measures, e.g., as already identified in Baseline Studies or collected in the many stakeholder workshops, the so called Delta Ateliers in locations all over the country. The joint fact finding in the Delta Ateliers, with contributions from many local participants, played an important role in the BDP strategy process, as analysis and design workshops with active participation of stakeholders from almost all districts. The BDP2100-team gained valuable insights and understanding in these sessions about the situations on the ground, about what already has been done or was under construction and also what interesting ideas and possible options are in line with the Delta Goals, Mission and Vision. The problem analysis has been based on these findings and was subsequently focused on specific problems in so called Hotspot Areas (analytic clusters of similar specific problems) and on more general, cross cutting issues and challenges.

As the map in Figure 12.1 shows, the six Hotspot areas are the Coastal Zone, the Barind Region, the *Haor* Region, the Chittagong Hill Tracts (CHT), Rivers and Estuary and Urban Areas. As mentioned earlier, the main issues and challenges in the Coastal Zone are storm surges, sea level rise, salinization, water logging, erosion, sedimentation and land accretion. In the Barind and other drought prone areas, we find among others agricultural drought with attention for retention and ground water management. The *Haor* area shows flash floods, village protection issues and drainage problems. The Chittagong Hill Tracts have specific water management and climate issues of the hilly areas, including landslides, drainage problems and water supply. The Rivers and Estuaries areas are confronted with, e.g., flooding, riverbank erosion, sedimentation and land reclamation, reduced drainage capacity, water pollution. The Urban areas struggle with drainage capacity, water logging, water pollution and water supply and sanitation. Cross cutting issues and challenges are flooding and fresh water supply, including water supply and sanitation as well as environmental and ecological degradation. These issues and challenges have been elaborated and play an important role in the strategy formulation on the national level as well as for the six Hotspots. Besides, given the broad functions of water in society, a number of Thematic Strategies have been provided: (i) Sustainable Land Use and Spatial Planning; (ii) Agriculture, Food Security, Nutrition and Livelihoods; (iii) Transboundary Water Management; (iv) Making the Inland Water Transport System more dynamic; (v) Advancing the Blue Economy (coastal and territorial sea areas); (vi) Renewable Energy; (vii) Earthquakes.

12.3.5 The Adaptive Approach as Link Between Short-to Medium Term Targets and Long-Term Goals

As is well known by strategists and policy makers, strategies and measures have a certain design lifetime and might fail as the operating conditions change. Once strategies and measures are not effective anymore, compensating or other measures are needed to achieve the desired delta vision and goals. It is therefore necessary to monitor the operating conditions and study the developments and drivers behind them. If, e.g., climate change accelerates, the related phenomena as SLR,

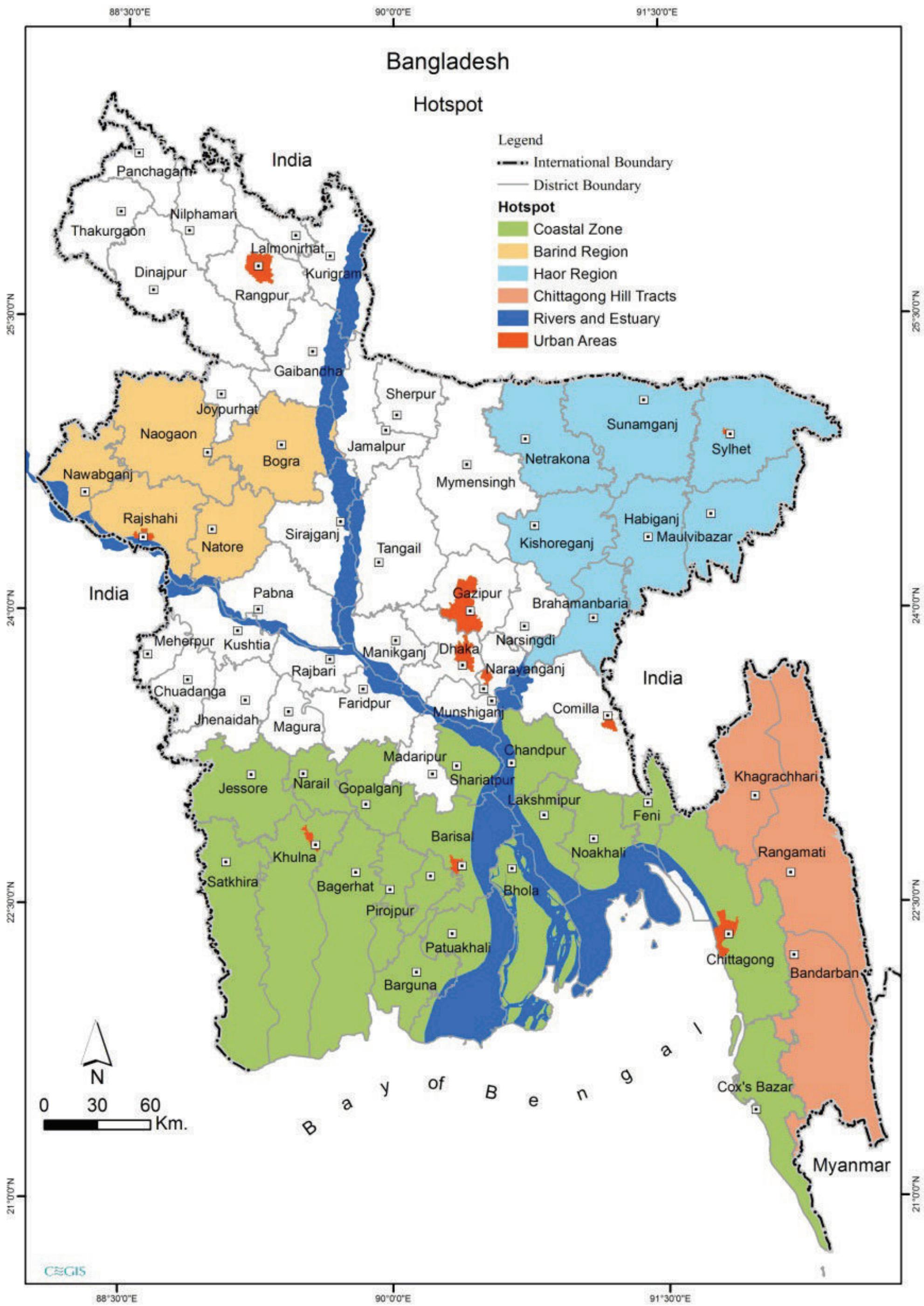


Figure 12.1: The Six BDP2100 Hotspot Areas

temperature, precipitation and occurrence of cyclones may change accordingly, impacting the operating conditions in the delta. The scenarios and strategies will need to be updated frequently as new information comes available in a five-year cycle. This adaptive approach to delta planning, including selection of investment projects, provides the link between the short-to-medium-term targets and investment programs with the long-term goals of sustained development based on climate sensitive management. This also underscores the importance of establishing a Delta knowledge portal and data bank and doing sound result based monitoring and evaluation to assess progress and problems.

12.4 STRATEGIES

12.4.1 Water

Water remains an indispensable resource and is used in diversified ways, for production purposes such as, agriculture, industry, commerce, forestry, fisheries etc., as well as for community services like use of water for domestic consumption and sanitation. The nation-wide demand for water is growing every day, which is being intensified by several socio-technical drivers such as high demographic changes, rapid and unplanned urbanization, high sectoral demand (agriculture, fisheries, transportation, industries etc.), climate change etc. On the other hand, the essentiality of water for the rich but vulnerable ecosystem of the country and the variability of water availability in dry and wet season, complicate the issue of water resources management in Bangladesh. The management of water resources is even made more complex by the fact that the catchment area of 93% of the flow generated in the Ganges-the Brahmaputra-the Meghna (GBM) basin, is lying outside the border of Bangladesh and is drained out to the Bay of Bengal.

The BDP2100 develops an adaptive, holistic and long-term strategic plan to steer the opportunities and vulnerabilities created by the interface of water, climate change, natural disasters, environment, ecological balance, agriculture, land use and inland water management for national development. The sustainable multi-sectoral use of water resources and prevention of water-related natural disasters provides the backbone to the Delta Plan. The strategies for managing water resources in wet and dry seasons that have been formulated, are flexible in respect of measures and actions with its timeframe and uncertainties. The strategies are adaptive in the sense that they need periodic review and update in Five Year Planning cycles on the basis of the actual situation and development needs. These strategies contain many ‘no regret’ measures in a sense of effectiveness and maximum benefit, and offers integrated implementation with innovation, advanced information technology and strengthened institutional capacity.

The water challenges and proposed strategies in BDP2100 are built around addressing the fundamental problem of flooding that is a nation-wide challenge and addressing "hotspot" specific challenges, i.e., water shortage in Barind and drought prone areas; river erosion problems of the river and estuary region; coastal inundation and salinity problems of the coastal region; flash-flooding and wetland management issues of the *Haor* area; water shortage, sanitation and drainage problems of the urban region; and the water shortage problem of the CHT.

12.4.2 Agriculture, Fisheries, Livestock and Forestry

Agriculture is most vulnerable to climate change. Considerable adaptation efforts of the past have helped lower the cost to agriculture. Nevertheless, several additional initiatives are necessary to cope with the growing risk of climate change for agriculture and livelihoods (see also Chapter 7). The implementation of water strategies and interventions are a major part of protecting agriculture from the adverse effects of natural disasters and climate change. Other strategic elements relate to the adoption of proper technology to combat salinity and rising temperature and to strengthen drought tolerance, and the institution of proper land management. Diversification of agriculture and preservation of food security requires stronger policy attention to non-crop agriculture that provides essential nutrition and balanced diet choices, including growing fruits and vegetables, fisheries, dairy farming and livestock (see Chapter 6). In particular, the delta location with multitude of rivers, lakes and ponds, and open access to sea, provides Bangladesh with rich opportunities to develop and benefit from a prosperous fisheries industry (see Chapter 5). Preserving the forest cover to maintain bio-diversity and ecological balance also allows protection from natural hazards. Sustainable forestry can also provide livelihood support to poor people when combined with a broad-based livelihood support strategy (see also Chapter 4).

12.4.3 Urban Areas

The country's current urban centers will continue their growth in the coming decades under the influence of rural-urban migration and by 2045 the majority of the population is expected to live in cities. Although the focus is on the water-related issues in this strategy, it is important to consider the wider context and challenges that face urban areas now and in the future. More general urban planning issues, such as uncontrolled urban growth and haphazard development have a close connection to water-related issues, like flood risk management. Underlying issues include high population density and various socio-economic and political factors that are responsible for the currently challenged state of urban service delivery. The impact and effectiveness of the strategies in dealing with water-related and more general urbanization issues have been considered. Strategies include:

- Increase drainage capacity and reduce flood risk and waterlogging in urban areas.

- Enhance water security and water use efficiency in the urban areas.
- Regulate and monitor river and other water body pollution from industries and human sources.
- Conserve and preserve urban wetlands and ecosystems and foster their wise-use.
- Develop effective urban institutions and governance.
- Promote integrated and sustainable use of urban land and water resources.
- Improve urban services: water supply, sanitation, waste-water and solid waste management. Place special emphasis on management of disposal of medical, electronic and other hazardous waste/materials.
- Control and monitor water pollution caused by industry and other sources.

12.4.4 Land Management

Land resource management is integrally linked to water resource management. Given the location and topography of Bangladesh, its land resources management is constrained by a great number of factors. Floods, drainage congestion and water-logging, drought, coastal/tidal surge, soil salinity, river bank erosion, soil erosion, soil fertility depletion, decrease of land productivity, siltation on river beds and canals, rise of sea water due to climate change, increase of population, urban and rural settlements and decrease of crop land are creating different challenges. With population growth and declining per capita availability of land, Bangladesh also faces land degradation. Deforestation, cultivation on steep slopes, shifting cultivation, over-exploitation of ground water, unbalanced use of fertilizers, improper crop rotations, are responsible for human induced land degradation. All these phenomena mean that the availability of land for crop agriculture will continue to decline, calling for policies, reforms, and technological innovations for not only raising productivity and reducing soil degradation, but also diversifying the crops to better respond to food security needs especially in the face of climate change.

Many land reform initiatives have been adopted but effectiveness was limited due to the inadequate attention to land governance, institutions and land markets. So, the main priorities under BDP2100 are: undertake a comprehensive public sector reform involving Ministries/Institutions dealing with land administration; modernization of land management through the Digital Land Management System (DLMS); computerization of processes and use of ITC for all land transactions; comprehensive review and reform of the National Land Use Policy (2001) to make it applicable for all land use throughout the country; reform of the regulatory policies for land accretion and reclamation to counter land grabbing and other practices (see also Chapter 8); adoption of a comprehensive land zoning policy that is sensitive to climate change and water hazard risks; and adoption of a water-sensitive spatial land use planning.

12.4.5 Environment, Ecology and Biodiversity

Wetlands are precious for the environment, ecology, and biodiversity. They are an integral part of the local ecosystem and closely related with local cultures, and also support the livelihoods of millions of people based on diverse activities such as fishing and agriculture. There is an urgent need to take action against wetlands degradation and maintain them through proper management. Strategic considerations include: conservation and preservation of wetlands and ecosystem through institutional capacity building, research and awareness raising programs; restoration of the Chalan *Beel* and the Halda River; establishing greenbelt around the hills of the Kaptai Lake; and preserving the Sundarban mangrove forest and parts of the *Haor* Basin wetlands.

12.4.6 Inland Water Transport

Being a land of rivers, inland waterway transport (IWT) has always been a natural, environment friendly and relatively cheap mode of transport for Bangladesh. An estimated 25% percent of the rural population has access to inland navigation. Inland waterways have continued to be important –sometimes the only — transportation mode not only for maintaining transport links between various remote parts of the country; it is a means of transporting export-import cargo as well. It provides cheaper transit of passengers and goods. Despite being the cheapest mode of transport, the popularity of IWT as a mode of passenger– and cargo transportation has seen a strong decline. IWT has suffered because many rivers of the country have been deteriorating due to natural, morphological processes and withdrawal of water from the rivers beyond the border and within the country, causing decreased dry season navigability. This was further aggravated by poor or no maintenance of waterways, weak regulations and safety standards, low allocation of budgetary funds and general under-investment by both public and private sectors.

The prospects for inland water transport have improved, given the rapid GDP growth and associated demand for passenger– and cargo services along with constraints in developing road and railway transport. There is now a growing appreciation that with proper investments, policies, regulations and institutional development the IWT can be a major low-cost transport alternative to the high-cost land transport. The positive effects of this strategy for income, employment and poverty reduction are large. Looking forward, the IWT strategy will need to focus on the following main priorities: systematically and substantially address the river morphology and climate change issues affecting IWT; select priority routes and maintain them adequately; develop and modernize priority route infrastructure as an integral part of the multimodal connectivity; substantially increase public and private investment in IWT; improve IWT governance, administration and safety standards; strengthen cross-boundary river traffic through joint investments in infrastructure and proper cost recovery policies.

12.4.7 Blue Economy

With the settlement of maritime border disputes with neighboring states Myanmar and India in 2014, the Government of Bangladesh embarked on a process to unlock the potentials. The blue economy is now considered as a new "development space" in Bangladesh. Shipping, sea ports, ship building and recycling, marine fisheries, sea salt production, coastal tourism, ocean energy, land reclamation, maritime surveillance, human resources development and governance have been identified as key priority sectors for the development of the blue economy.

12.5 GOVERNANCE AND INSTITUTIONS

12.5.1 Broad Principles, Issues and Challenges

The Delta Plan agenda is essentially cross-sectoral, focused on "delta governance" instead of sectoral water management, and on implementation arrangements involving multiple line ministries, local government institutions, communities and private sector. Clarity of role, interdependence of actions and a coordinated approach are essential requirements of the institutional set up for Delta Plan implementation. Institutions are dynamic in the sense that they evolve over time. Starting with a thoughtful design that involves pragmatic solutions based on the present socio-political realities of Bangladesh and recognizing capacity constraints in public administration, institutional changes need to be made. The immediate challenge is to develop basic minimum core arrangements now, without which the implementation of the Delta Plan strategies will be difficult.

Some of the broad principles and features of the global institutional practices in delta management can be summarized as follows: importance of holistic water management and multi-sectoral coordination; need for effective transboundary water cooperation; strong and participatory institutions for national and local water cooperation; focus on knowledge for adaptive delta management; emphasis on public-private partnerships; coordinated approach to Delta Plan financing with emphasis on the beneficiary pays principle; and effective monitoring and evaluation.

Bangladesh has more than 60 years of experience in managing water resources that is reflected in numerous water policies and water programs. Despite this rich history, the enactment of the 2013 Water Act and the high-powered coordinating committees (NWRC, ECNWRC), effectiveness of the implementation of integrated water management is weak. Integration of water with other challenges of the Bangladesh Delta including a clear link to development outcomes does not exist. The gap between the good practice of international experiences and governance and institutional performance is large. Successive governments have engaged in detailed technical studies with international technical experts, but implementation has suffered owing to political, financing and institutional constraints. At the institutional level, the main problem is the reduced capacity of water related institutions. A second problem is that water management organizations, especially concerning water users in all involved sectors, throughout the country are absent, with exception of a number of project-based experiences. A third problem is the lack of integration of water issues with climate change, environment, land management and other delta-related challenges owing to inadequate institutional coordination.

To overcome the issues and challenges, the following nine key elements of the governance and institutions under the BDP2100 have been identified (see section 12.5.2 to 12.5.10).

12.5.2 Coordination and Facilitation of BDP2100 Implementation

The government has agreed to assign the General Economics Division (GED) the responsibility of overall coordination, facilitation and M&E of BDP2100 implementation as well as frequent updating of the Delta Plan. Institutional capacity of GED needs to be enhanced for carrying out these tasks in an integrated and holistic manner for which already a Delta Wing has been created. The "Delta Governance Council (DGC)" is proposed as a small but high-level inter-ministerial forum chaired by the Hon'ble Prime Minister. DGC is proposed as a supervising and guiding entity and the Planning Minister would be the Vice-Chair. The DGC would function as a formal linkage for achieving political commitments regarding BDP2100 and its implementation, provide directions and to make decisions. It would provide strategic advice and policy guidelines. To facilitate specific project/program selection for inclusion in the Delta Plan Investment Program, a second coordinating committee named as Delta Plan Project/Program Selection Committee (PPSC) will be established chaired by Planning Commission Member GED and comprising of representatives of Finance, Planning, Water, Environment and Forestry, Agriculture, Land, Livestock, Fisheries and Shipping. The Delta Wing under GED provides input to these Committees as BDP2100 coordinating body concerned with multi sectoral coordination of investments, knowledge management, and facilitating the implementation of the BDP2100 including the linkage with the Delta Fund, monitoring of the Delta Plan implementation and updating the Delta Plan. Actual implementation of BDP2100 approved programs and projects will be undertaken under the umbrella of the Five Year Plans by related ministries and implementing agencies following the normal procedures.

12.5.3 Bangladesh Delta Fund

Bangladesh presently spends about 0.8% of GDP for water resources, mostly for new investments, which will increase gradually up to 2.5% by 2030. The delta spending program will be prepared and updated on a five-yearly and on an annual basis by GED and will include investments, O&M funding, research, capacity building and institutional development. Approved programs will be guaranteed funding for the full life of the project and proper balance between new projects and completion of ongoing projects will be ensured.

12.5.4 Local Water Management Bodies

The missing multi sectoral water user institution in Bangladesh is the representation in decision making of Water Users Institutions with beneficiary stakeholders linked with multi sectoral aspects and interests in coastal zone management, river management, freshwater wetlands (*haor*s and *baor*s) management, large irrigation schemes and flood control. Establishment of this missing link in Delta Management is an essential reform for successful management of the BDP2100. These water user bodies fundamentally must represent the stakeholders and not government interests. The water user bodies should be established based on a careful review of international experiences, analysis of the past approaches to establishing water-users associations in Bangladesh and of the reasons for their failure.

12.5.5 Strengthening Core Delta Institutions

Strengthening the core delta institutions for the BDP2100 implementation is of crucial importance to achieve the Vision and Goals and also for the efficient implementation of the Delta Plan itself. This is a tough challenge and involves long term effort. Yet some core implementation related institutions require support and development soon, like GED, BWDB, DOE, DOF and DAE. The Ministry of Water Resources is the primary water management institution in the country. Its work is supported by a number of specialized agencies including the two core institutions: BWDB and WARPO. Both institutions need considerable strengthening in terms of new technology, innovation, integrated planning, research, economic management and consultative processes. BWDB will also need to help out with the establishment of the local water user bodies and learn to work with them collegially as a complementary institution. The evolution of decentralized water user institutions will face some challenges. GED, WARPO and BWDB can make this process smoother and less costly through proper support and coordination.

12.5.6 Strengthening Transboundary Dialogue and Related Institutions

As a lower riparian, Bangladesh faces some real risks from adverse upstream developments. The ability to think innovatively requires both diplomacy and technical skills. These skills are required to come up with well thought out and multi-purpose river basin projects. Accordingly, the capacity of the Joint Rivers Commission (JRC) will have to be strengthened. Partnership and coordination of JRC with GED, WARPO, BWDB and other related institutions will need to be strengthened. Possible multi-purpose technical options and cost-benefit analyses of these options will need to be developed as background research to the dialogue with riparian countries. Routine dialogue involving exchange of pleasantries and general-purpose concerns/complaints and information sharing, must give way to strategic dialogue aimed at problem solving and finding solutions. The strategic dialogue needs to follow an approach of water diplomacy, aiming at win-win outcomes rather than the zero-sum approach which was followed earlier. Satisfactory progress with trans-boundary water management will have far-reaching consequences including lower-cost water solutions for Bangladesh.

12.5.7 Creating Knowledge Management with Information/Data Portal

BDP2100 provides a Knowledge Management approach to Delta Plan formulation, implementation and updating. The comprehensive knowledge domains of delta issues as well as the adaptive nature of delta management emphasize the importance of knowledge management and the requirement of an approach to identify and overcome knowledge gaps. Five elements of such an approach are: (a) Knowledge needs and agenda; (b) Knowledge accumulation; (c) Knowledge availability; (d) Value realization; (e) Delta Knowledge Community. In this approach, the creation of an information portal with data bank is an essential pre-requisite for undertaking adaptive delta management. This responsibility has been assigned to GED, who creates a knowledge unit with three main responsibilities: (a) collate all relevant delta related knowledge globally and nationally into a digitized knowledge library; (b) establish a delta data bank; (c) develop and implement a comprehensive delta knowledge and data updating effort.

12.5.8 Developing Monitoring and Evaluation (M&E) System

The practice of conducting M&E of government policies and programs is usually project based but needs to have a stronger link with Bangladesh strategic planning. A dedicated result-based M&E effort is essential for sound implementation of the BDP2100 in relation to reflection on outcomes and considerations of necessary adaptation in line with achievement of Delta Goals and Vision.

12.5.9 Reviewing and Updating of BDP2100

As the BDP2100 is an adaptive and long-term plan, it has been integrated with the planning process of the country. It should be periodically and regularly reviewed and incorporated in future Five Year Plans routinely, and subsequently in annual budget allocations. Moreover, integration with new knowledge and technologies is necessary to enhance the present status of the plan in the long-term perspective of Goal and Vision achievement. Its implementation also requires continuous monitoring and evaluation in the future.

12.6 BDP2100 FINANCING NEEDS AND FUNDING

The GoB indicated that implementation of the Delta Plan involves a total spending on delta-related interventions, through new projects and maintenance of new and old projects, to an amount of about 2.5% of GDP per annum. This compares with an annual spending of 0.8% of GDP presently. The additional investment and operation and maintenance (O&M) costs for implementing the Delta Plan of about 1.7% of GDP per year, consist of 1.2% from the GoB budget and 0.5% from private sector investments. The level of 0.5% from the private sector requires development over time (in the next 5 to 10 years) to overcome the current obstacles, to build up a Public-Private-Partnership (PPP) enabling environment and a PPP project pipeline in the BDP related sectors. Finding the additional 1.2% of GDP for public financing of the Delta Plan follows a strategy for public funding, with some combination of tax financing, application of cost recovery based on the principle that the beneficiary pays and mobilizing foreign funding including tapping into the global Green Climate Fund (GCF).

12.6.1 Cost-Recovery by Beneficiary Payments

International experience with Delta management shows the strong role of the application of the beneficiary pays principle in financing water related investments. For example, in the Dutch Delta much of the funding of flood control, water supply, sanitation and waste management investments is financed by users via taxes or cost recovery mechanisms. The O&M is fully funded through national tax and regional water board tax based on cost recovery. In the Netherlands, water management is largely decentralized. Some 80% of the spending including 100% of O&M is done by local water boards, municipalities and drinking water supply companies.

There is certainly a scope for application of dedicated taxes and the beneficiary pays principle in Bangladesh Delta management. In Bangladesh O&M funding of urban water and sanitation is prevalent in significant ways. However, cost recovery of O&M does not happen. There is no cost recovery yet of capital cost of urban water supply, sanitation and waste management. Regarding flood control and irrigation, there is, with some rare exceptions (see for instance Chapter 3), no cost recovery of either capital cost or O&M. Regarding urban water and sanitation, the institutions and regulations are in place. Over time, consideration may be given to recovering capital costs, starting with the relatively well-off service areas of the four WASAs. Regarding solid waste, cost recovery can happen through an annual service charge linked with the setting up of a modern property tax system.

12.6.2 International Financing

Naturally, GoB funding and foreign sources, including loans and grants from bilateral donors and IFIs, can significantly contribute to the realization of BDP2100.

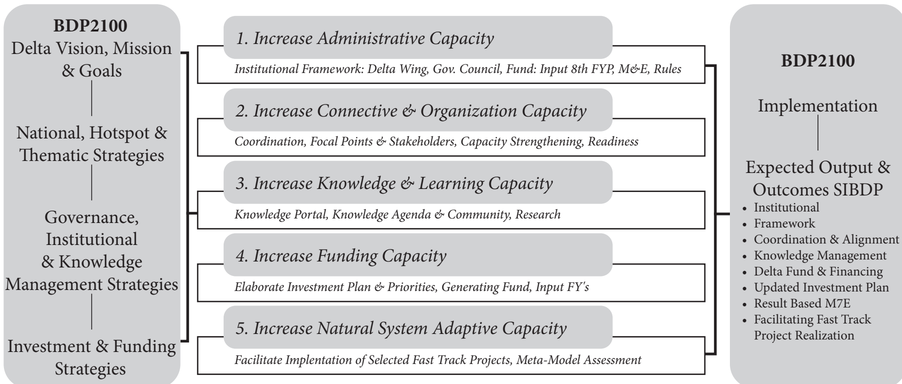
Additional international grant financing for Delta Plan can be secured by effectively tapping resources from the global Green Climate Fund. As such, it is well placed to tap this important source of grant funding to scale up delta investments. The Delta Plan also expects investments from the private sector. Exploration of options and establishing a clear and stable institutional framework is needed to ensure private enterprises they can play a crucial role in the fight against climate change.

Effective engagement of the private sector will generate sizable resources to finance the Delta Plan. It is expected, that on average Bangladesh should (in the mid– and long-term) be able to mobilize at least 0.5% of GDP per year for private sector financing of water– and related infrastructure. International experience shows that the prospects for attracting private investments including through public-private-partnerships in wastewater treatment, water supply and sewage treatment, are good. Another prospective area is irrigation. A third area is dredging. There is strong private sector interest in undertaking dredging contracts, especially when longer stretches are contracted for a multi-annual (e.g., 5 years) period. Bangladesh can learn from international experience in developing the proper contracting arrangements for dredging. A fourth area for private sector involvement concerns land reclamation and development. Combining land reclamation with dredging of rivers, e.g., in a PPP concession framework would make sense. Finally, the private sector could be involved in port-development and related infrastructure and warehousing facilities for inland water transport (IWT).

12.7 IMPLEMENTATION CAPACITY

12.7.1 General Observations and Kinds of Capacities

The outcomes of the BDP2100-approval process are key to the implementation of the Plan, with respect to the strategies and investment plan, the institutional setting and financial ambitions. Despite the extensive experience in managing water resources, the effectiveness of implementation of integrated water management in a multi sectoral way is weak. The reasons are: (i) weak capacity of water and water related institutions; (ii) absence of water management organizations nearly throughout the country; (iii) lack of integration of water issues with the needs of other sectors and with climate change, environment, land use management and other delta-related challenges. The monitoring and evaluation of policy implementation, especially when more than one sector is involved, is also weak. In relation to this and with respect to substantial new investments and adequate financing arrangements, improvement of Delta governance and the institutional arrangements is needed to implement the Delta Plan. In its "Summary of Delta Governance and Institutional Reforms" the Plan provides a series of proposed reforms and required actions. Here, we follow this overview. The Plan elaborates on investments, implementation and governance and institutional matters. In connection with the above analysis and approach and based on experiences with strategy making and implementation, five implementation capacities are necessary for effective BDP2100 implementation and must be addressed in order to achieve expected results. These five capacities are shown in Figure 12.2 and are briefly explained below.



Source: J.M. de Heer, Twynstra Gudde Advisors, Proposal to SIBDP Project, 2018.

Figure 12.2: Five Implementation Capacities for Achieving Vision, Goals and BDP2100 Implementation

12.7.2 Administrative Capacity

Implementation of a huge and significant plan like BDP2100 requires an adequate institutional framework to make further operationalization and execution legal and possible. Integration of BDP2100 into the legal framework, governance rules, regulations and national planning cycle is needed to mainstream BDP2100 within policies and plans like the National Five Year Plans, the (draft) Perspective Plan 2041 and the yearly budget allocations. Furthermore, a legal and strong institutional basis is required for integration and coordination of the multi-sectoral tasks, for monitoring and evaluation and for cyclical updating and mainstreaming, as well as for decision making and fund allocation for investments. For performance of these tasks, GoB decided to form a Delta Governance Council, a Project/Program Selection Committee, a Delta Fund and a GED-Delta Wing. By this overhaul, the administrative capacity for BDP2100 implementation and follow up will increase considerably.

12.7.3 Connective– and Organization Capacity

Prerequisites to implement a multi-sectoral plan are interaction and coordination as well as "readiness" of involved implementing agencies, knowledge institutions and main stakeholders. Readiness means being prepared to implement: (1) knowing and being trained on the BDP2100 content with its methodology and strategies; (2) bringing involved agencies in good shape (e.g., mandates, rules, structure and tasks, processes, human and financial resources, other capacities); (3) contributing in execution of projects. BDP2100 implementation requires strong emphasis on coordination and mutual interaction, creating an implementation network with pro-active focal points and effective procedures for micro planning, decision-making, funding and project execution. These elements and training will be part of capacity strengthening as indicated in the project document.

12.7.4 Knowledge and Learning Capacity

Implementation can only take place when necessary information, data, maps and knowledge of enough quality are available. Knowledge management, research and learning are therefore of crucial importance in implementing an adaptive delta plan. Data, information and understanding are needed to deal with the drivers of change and development in a pragmatic way, supporting and managing interventions in the natural system as well as in institutional–, organizational–, management– and financial matters. This will build on the already developed Knowledge Agenda (with a possible research program with Dutch NWO), the created Information Portal and data layers. Additionally, a 3-yearly periodic review of BDP2100 implementation will offer systematic insight in progress of implementation, natural system behaviour and goal achievement.

12.7.5 Funding Capacity

Proper investment planning, funding and financial mechanisms are a must to any implementation. Especially for the implementation, BDP2100 committed a provision of 2.5% of GDP annually. Nevertheless, additional financial resources still need to be allocated by the GoB, development partners, and IFIs with a linkage to, e.g., the Green Climate Fund and Public-Private Partnerships. Updating the Investment Plan and building trust and relationships with development partners and IFIs to achieve this are important elements.

12.7.6 Natural System Adaptive Capacity

BDP2100 implementation builds on the planning exercise, which delivered project preparations and investment priorities for effective interventions in the natural system of rivers, of the coastal zone, the *Haor* system etc. For each Hotspot area, projects were selected with already available (pre)feasibility studies which after final approval and financing can be implemented. Projects are selected with stakeholders, and are tested for coherence and goal achievement, improved where needed and programmed for Fast Track implementation. Implementation requires a well-considered approach, a systematic sequence and involvement of stakeholders. To facilitate this, the National–, Hotspot– and Thematic strategies are being elaborated into focused River Basin Development Plans, a Coastal Zone Development Plan, and possibly an Urban Integrated Water Development Plan, to be developed in close interaction with stakeholders. The foreseen manner of assessment (based on the so-called Meta-Model) offers promising next steps to support decision-making on selection of adaptive interventions and investments.

12.8 CONCLUSION

The Government of Bangladesh decided to embark on the formulation of a long-term Bangladesh Development Plan 2100 to address the challenges posed to security and livelihoods of the population by natural hazards and the consequences of climate change in close connection to the socio-economic development and food security of the country. The Plan applies the Adaptive Delta Management approach and further elaborates this. This means in essence managing uncertainty and risks in a coherent multi-sectoral way, being prepared for immediate threats and able to adapt as and when required or when better solutions become available. As such, the Plan is a unique example of ADM with its long-term orientation and short-term action programs. The improvement of institutional implementation capacity has been elaborated and actual steps in this direction have already been taken. An Investment Plan is an integral part of BDP2100 and involves delta-related interventions through new projects as well as maintenance of old and new projects. It is of utmost importance that the Plan is indeed energetically carried out and frequently updated, financially supported by development partners, and international funds and institutions. It is encouraging that a project was initiated especially geared towards this objective, "Support to Implementation of BDP2100", funded by the Netherlands Embassy and hosted at the General Economics Division of the Planning Commission.

The Plan covers the whole of the delta area, with emphasis on six so-called Hotspots, the coastal zone one being one of them. The next chapter is devoted to this zone, including the dynamic, central part, the main focus of this book.

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Chapter 13

Meaning of BDP2100 for the Coastal Zone: Coastal Development in BDP2100 Perspective

Dr. Jaap M. de Heer, William Oliemans and Giasuddin Choudhury

13.1 OVERVIEW OF COASTAL ZONE ISSUES AND CHALLENGES

The coastal zone of Bangladesh is one of the six Hotspot Areas distinguished in the Delta Plan (see Chapter 12) because of the specific characteristics along the coast. The coastal zone shows a large variation in these features (see also Chapter 1) and has an enormous potential for opportunities of national importance. Examples are indicated in the Delta Plan under the label of "Blue Economy" and concern intensification and diversification of agriculture, aqua-culture and marine fisheries, exploration of gas and oil resources, development of the ship building industry, eco-tourism, renewable energy and deep sea-port development. Bangladesh's rapid economic development is also noticeable in the coastal region, with small and medium sized industries being set up near urban centers, port development and the anticipated development of the Kolkata-China corridor, of which the new Padma bridge is a key component. Unfortunately, the coastal zone of Bangladesh is also a disaster-prone area. Cyclones, storm surges, droughts, floods, waterlogging and salinity intrusion have a huge impact on people and their livelihood. Poor communication, lack of education and health care facilities, prolonged absence of safe drinking water and insufficient cyclone shelters contribute and multiply the dimension of vulnerability. Furthermore, growing population pressure increases the competition for limited resources. As a consequence, in order to unlock these potentials and address the threats, existing and new interventions are required in an integrated and inclusive way, calling for a distinct and integrated coastal development strategy.

The coastal zone of Bangladesh covers some 35% of the country and houses 25% of its population. It is estimated that some 30% of its GDP is created here. Key features include the Sundarbans; the world's largest mangrove reserve and a UNESCO World Heritage site, the Meghna Estuary, a highly active delta estuary where both erosion and sedimentation lead to an estimated accretion of more than 15 km^2 on an annual basis and the Chittagong-Cox's Bazar coastline, an area with high industrial and tourism potential. Seaward, the Exclusive Economic Zone covers a large area in the Bay of Bengal. Figure 13.1 gives the total overview of the coastal– and related seaward area which is of importance for the Blue Economy approach.

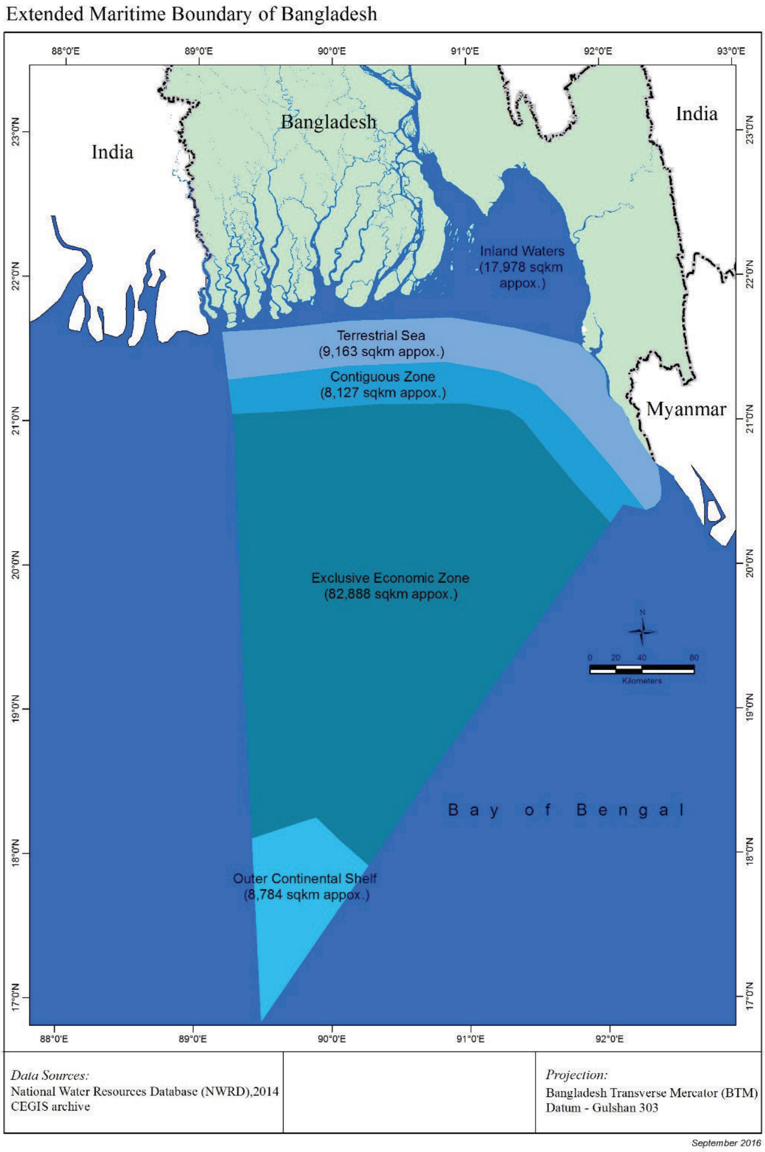


Figure 13.1: Coastal Zone and Exclusive Economic Zone (EEZ)

The Delta Plan considers the following five issues as key in the coastal zone: floods, waterlogging, riverbank and coastal erosion, freshwater availability and environmental degradation (respectively section 13.1.1 to 13.1.5).

13.1.1 Floods

In the coastal area we distinguish between annual rainwater and riverine flooding, which occur in the whole country, tidal floods and storm surges, unique features in the coastal zone. Tidal floods, e.g., during spring tide, may cause severe loss on unprotected coastal lands as well as sometimes breach earthen embankments, leading to potentially more harm. The northern and eastern part of the coastal zone is also prone to riverine floods, often aggravated by coincident high tides. Only the western part is relatively better protected because of the extensive Mangrove forest of the Sundarbans, naturally reducing wave heights. The Chittagong coastal floodplain is particularly prone to flash floods, coming from the Hill Tracts. Riverine floods show a potentially larger flood extent than storm surges, however, storm surges lead to larger water depths, particularly in the sea-facing areas. The floods are potentially harmful to a large population (more than 30 million people), leading to severe productivity and livelihood losses and extensive damage. Considering above flood types, the largest exogenous drivers for future change are: (1) sea level rise and subsidence; (2) change in frequency and severity of cyclones and accompanying storm-surges; (3) increase in peak discharges (and sediment flow) for the main rivers of Bangladesh; (4) population growth and urbanization; (5) (regional) economic development and diversification.

The BDP2100 Delta-scenarios, based on the Climate Change Baseline Study, state that in general sea level rise in the Bay of Bengal is projected to range between 20-30 cm (2050) and 40-60 cm (2100) in a moderate climate change scenario up to 40-60 cm (2050) and 80-125 cm (2100) in a high climate change scenario. These projections will probably be adjusted upwards as a result of the latest IPCC scenarios. These projected numbers are excluding subsidence, which is estimated at 0.5 cm per year. The Delta scenarios need to be translated into flood hazards, making use of the existing models for the Bangladesh coast and impacts, specified for the above flood types. This will support the elaboration of different policy actions for the regions of the coast. Higher (relative) sea levels will increase surge height and tidal water levels. With the natural slow decrease of polder embankment levels, for cyclones with comparable frequencies to the current cyclones, the result will be increased overtopping or polder embankment breaching, as well as larger (salt) water depths in the exposed polder area. A projected higher frequency and severity of land falling cyclones and accompanying storm surges, as a consequence of increased sea surface temperature, may further aggravate flood hazards from sea. Areas that are now not prone to storm surges (and accompanying winds), will become prone due to climate change. Unprotected areas outside the polders, influenced by tidal flows and sufficient sediment supply, will naturally grow with sea level rise. Population growth, land use change and regional economic development, when they are not sufficiently adapted to future flood (and wind) hazards in the coastal zone, will also increase the coastal flood risk in the future. (see for the impact of climate change also Chapter 11).

In addition to the specific changes in flood risk from cyclones and storm surges, it is suggested that flood hazards locally occurring in the coastal zone related to river floods, flash floods and rainwater floods (leading to drainage congestion) may change, as well. The Delta-scenarios only provide figures now on the mean annual maximum discharge changes for the inflow points of the main rivers, but for these flood hazards and risks it is of more significance whether the frequency, timing and duration of more extreme discharges will change. The role of morphological impacts on flood risk should be further investigated. In such a future flood risk analysis, possible socio-economic changes should be included as well. These two issues are therefore prioritized as knowledge gaps for the Delta Plan.

13.1.2 Waterlogging

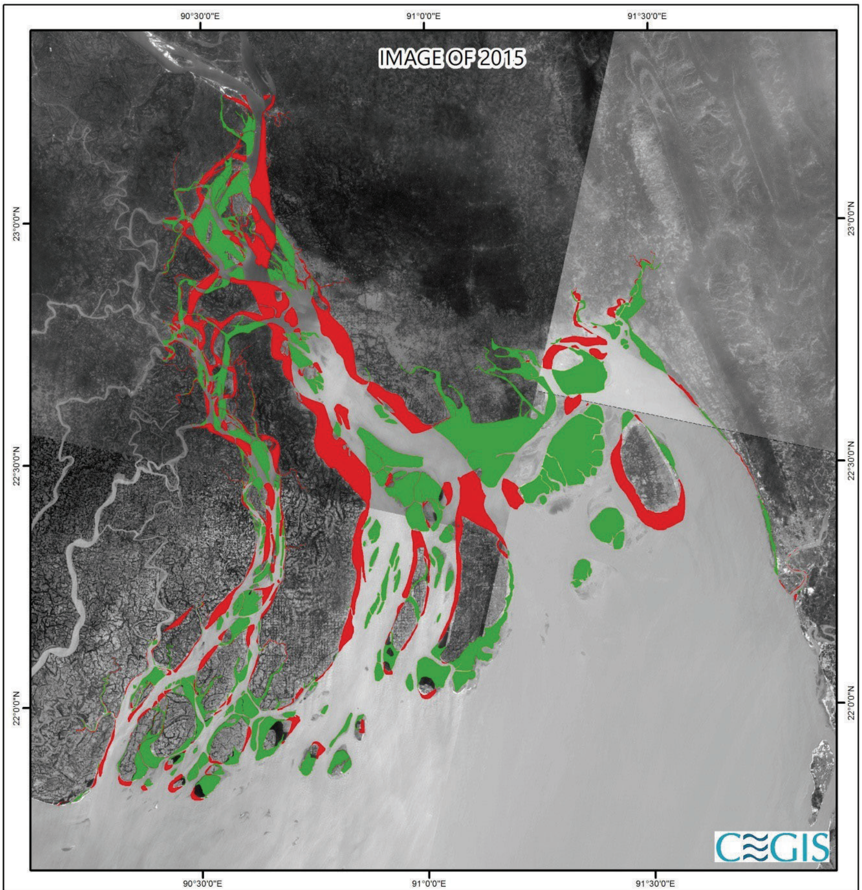
Several areas in the coastal zone (especially the western part and Noakhali mainland) suffer from extensive and permanent waterlogging. Reasons behind waterlogging are complex and differ between regions, as well as their expected future development. Drainage capacity of the area and of peripheral rivers, is a main concern and is expected to be heavily impacted in future conditions. The problem of waterlogging in the coastal polders, particularly in the Satkhira, Jessore, Khulna, Bagerhat and Noakhali Districts is the result of three separate though mutually interacting causes. The presence of coastal polders prevents the spreading of the natural tidal flows and restricts sedimentation in low lying areas. Consequently, sediment is deposited on the peripheral riverbeds, leading to large scale riverbed siltation and further reduction of the tidal prism. The silted river blocks the natural drainage (needed for the extensive monsoon rainfall) from the polders. This process is aggravated by the fact that polder infrastructure (khals and tidal sluices) does not function optimally, also due to ineffective O&M. In addition, the development of the road network inside the polders is acting as an internal embankment and is often designed without proper attention to drainage capacity. Waterlogging also occurs in Noakhali and Chandpur Districts, as a direct result of longer drainage paths due to land reclamation projects south of Noakhali and the natural process of delta progradation (growing). The many different causes for extensive waterlogging are only partly influenced by external driving forces identified in the Delta-scenarios. More intense rainfall events, lower upstream river flows in the dry season for the flushing of incoming sediment and reduction of tidal prism, climate change, sea level rise and subsidence will aggravate waterlogging experienced now. The areas that are currently not experiencing waterlogging (e.g., non-polder areas in Jhalokati, Patuakhali and Barisal districts) may experience that in the foreseeable future. Several causes directly related to human activity (e.g., floodplain encroachment, polderization, drainage infrastructure blocking and longer drainage paths) will, without policy changes, become more prominent under higher population pressure and changing economic activities in these areas. One of the suggested driving forces of waterlogging, riverbed sedimentation, also reduces navigation possibilities, fresh surface water supply as well as capture fisheries production. Logically, SLR will further aggravate waterlogging due to the raising of river water levels. This impact also needs to be studied further.

13.1.3 Riverbank and Coastal Erosion

In the dynamic morphological environment of Bangladesh, riverbank and coastal erosion will remain salient features. Large scale sediment transport in rivers is mainly activated due to higher discharges, which are projected to occur more often in the future in the Meghna Estuary. Sediment supply from the upstream catchment is another important factor, which is the topic of various scientific studies at present. It is however unclear, how much sediment load is available in the GBM basins, e.g., because of the impact of upstream developments, and how sediment transport is influenced by sea level rise and accompanying change in tidal influence (see also Chapter 2). Moreover, the fate of local riverbank and coastal sites vulnerable to erosion are difficult to predict in such a dynamic environment. These two issues are identified as knowledge gaps and included in the Knowledge Agenda of the Delta Plan. The CEIP research and monitoring project started a five-year research program aimed at better understanding of morphological processes in the coastal zone. Riverbank and coastal erosion occur on a large scale in the central Meghna Estuary, due to large discharges as well as a substantial sedimentation load. The tidal floodplain area, more to the west, is much more stable, but locally severe erosion is observed. Local riverbank erosion also occurs in the Chittagong floodplain, along the Karnafuli River. At household level erosion leads to loss of productive land, damage to houses and infrastructure, including embankments, markets, schools and navigation landing sites. If we consider the whole coastal zone, annual land accretion exceeds erosion, particularly in the Meghna estuary, see Figure 13.2 (extensively dealt with in Chapter 2).

13.1.4 Freshwater Availability

Large areas in the coastal zone (mostly in the western part) suffer from a deficit of freshwater availability, mostly in the dry season. Drinking water supply is a large problem for south-western regions, and shortages of freshwater are equally felt in agricultural production and in the highly vulnerable Sundarbans mangrove forest. Projected decreases of transboundary freshwater inflows, sea level rise, as well as possible unprecedented increases in specific demands, makes freshwater availability a dominant issue for the coastal zone. Freshwater availability for different sectors (e.g., agriculture, domestic, industrial, nature) in the coastal zone is challenging now (in particular in the Ganges Tidal Floodplain West and the more remote island areas) and will be further aggravated by changes in water levels and — flows, and by future socio-economic conditions. In the south-western part, uncertain dry season flow from the Ganges distributaries (upstream extractions, also in the Ganges Dependent Area, limited rainfall in GBM-basins and siltation), as well as sea level rise will shift the salinity front in surface and groundwater water at the end of the dry season to more northern areas, with dangerous consequences for livelihoods and the environment.



Erosion-Accretion in the Meghna Estuary Area during 1973-2015

District	Erosion (km²)	Accretion (km²)	Net accreted area (km²)	Rate of net accretion (km²/y)
Barisal	169	155	-14	-0.3
Bhola	385	396	11	0.3
Chandpur	76	44	-33	-0.8
Chittagong	105	256	151	3.6
Feni	11	30	19	0.4
Lakshmipur	133	53	-80	-1.9
Noakhali	179	620	441	10.5
Patuakhali	126	230	103	2.5
Shariatpur	20	27	7	0.2
Total	**1205**	**1810**	**605**	**14.4**

Legend

Erosion 1973-2015

Accretion 1973-2015

0 10 20 40 km

Figure 13.2: Gains and Losses of Land between 1973 and 2015

In the western tidal floodplain area, shrimp culture is progressing, sometimes in combination with rice production in the monsoon period. Along the gradient, also prawn and fish farming is increasingly practiced in order to adapt to the new situation. Freshwater supply for domestic needs is severely constrained due to the elevated salinity level in the shallower aquifer and arsenic contamination in the deeper aquifer. The south-central coastal zone is better fed by freshwater from the Arial Khan and Lower Meghna rivers, making this area less vulnerable for river sedimentation and salinization. However, because of its dynamic nature, navigation in this area remains a continuous matter of attention. Projected sea level rise will cause a higher difference in pressure between sea level and groundwater level. This difference may create an upward flow resulting in saline seepage inland near the coast. In this area, there are freshwater lenses which float on top of the saline groundwater, which are created by a vertical downward flow of rainwater. These rainwater lenses — which are very relevant for currently practiced agriculture — may be threatened by the saline seepage. Their volume of fresh water may be reduced as they are contaminated by the saline groundwater flowing upwards.

13.1.5 Environmental Degradation

In addition to problems related to the salinity balance in the Sundarbans and the threat to many wetlands in the coastal zone, floodplain connectivity, urbanization pressure and water quality issues (as a result of effluents from industry, agriculture and aquaculture), environmental degradation of natural resources will increase. Higher water demand, pollution and on-going urbanization/population growth will amount to even more pressure on the already sensitive wetland ecosystems and floodplain-river system. In the moderate and active scenarios of BDP2100, pressures will be driven mostly by population increase, urban sprawl and higher agricultural demand, as a result of which many *beel*s are at risk of further encroachment. Sources of contamination will be dominated by the domestic and agriculture sectors. In the productive and resilient scenarios of the Plan, pressures will be mostly driven by urban and industrial development with similar impacts on wetlands encroachment. Pollution from industrial and urban sources, will increase. Pollution with plastics on land as well as in the sea, will become a bigger challenge. An overview of the discussed issues is shown in Figure 13.3.

13.2 COASTAL ZONE STRATEGIES

The coastal zone shows many issues and challenges to be addressed from the perspective of water safety, water– and food security and socio-economic development. As mentioned earlier, the coastal area offers also a lot of opportunities, these include:

- Land reclamation, particularly in the Meghna Estuary;

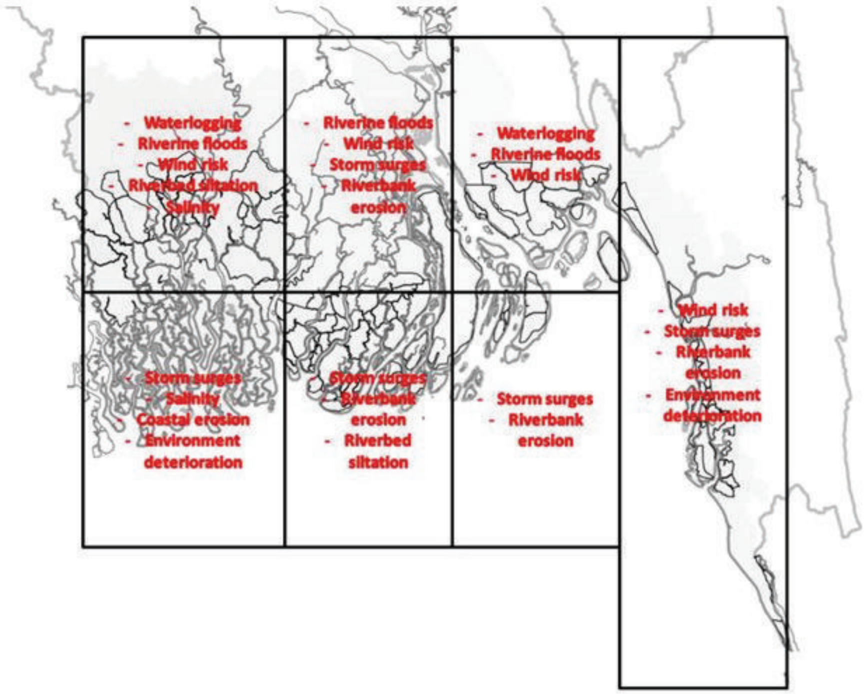


Figure 13.3: Issues in the Coastal Zone

- Agricultural intensification and transformation, particularly in the Ganges active floodplain;
- Aquaculture, particularly in the Ganges moribund floodplain;
- Conservation and enlarging eco-systems and biodiversity;
- Industrial development and logistics near future ports and major infrastructure developments such as the Bangladesh, China, India, Myanmar (BCIM)-corridor, Padma multipurpose bridge, Chittagong–Dhaka Navigation corridor;
- Water and nature related tourism.

The mentioned opportunities as such differ from each other; a balanced approach is important to unlock the optimum potentials of the coastal zone. Therefore, the BDP2100 strategies, against the background of the long-term vision and delta goals, contain the various aspects related to the mentioned opportunities.

The BDP2100 strategy formulation followed a funneling process from all possible strategies and interventions, to realistic strategies and next towards preferred strategies. During this process, the key issues and challenges as well as the opportunities were discussed with many stakeholders and experts, leading to the following strategic outcomes for the coastal zone. BDP2100 indicated two national level strategies which are important for the coastal zone: (1) the Flood Risk Strategy and (2) the Fresh Water Supply Strategy, which are (not exhaustive) elaborated below in section 13.2.1 and 13.2.2 respectively. In addition, four more subject-specific strategies will be dealt with below: drinking water supply (section 13.3.3), inland water transport (section 13.3.4), waterlogging and salinization (section 13.3.5) and reclamation of new land (section 13.3.6).

13.2.1 Flood Risk Strategy: Improve Drainage Capacity and Reduce Flood Risk in the Coastal Zone

A number of concepts play a role in the Flood Risk Strategy, as shown in Figure 13.4.

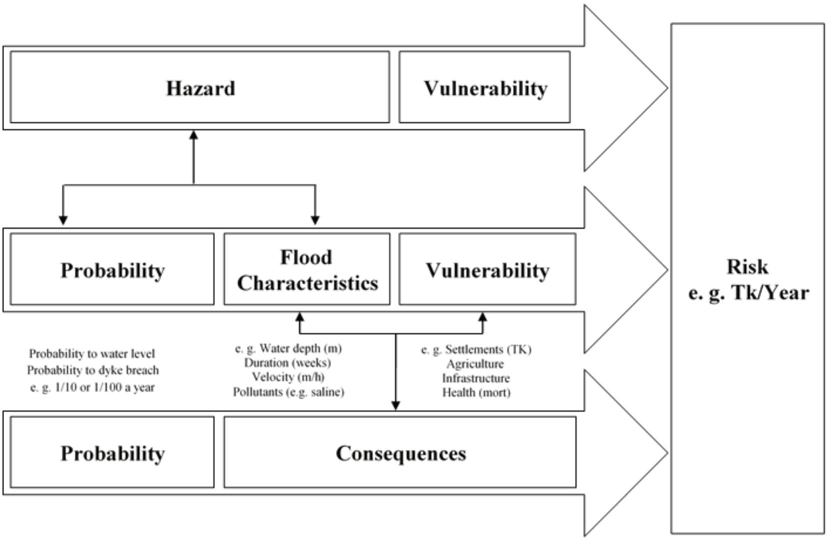


Figure 13.4: Flood Risk Concepts

Cyclone induced tidal surges occur in the coastal zone, basically consisting of large estuaries and low-lying lands, mainly during the pre– and post-monsoon periods. Cyclonic floods are the most disastrous of all, for which the fatality of lives increases and the damage to and loss of homesteads, critical infrastructures, crops and livestock is huge. Flash floods occur in the eastern coastal hilly regions. Flash floods have a relatively short duration, but generally have high velocities and a rapid increase in water levels. This makes them very destructive at local level. River floods are caused by spilling of water over the banks of major rivers due to heavy rains in the upstream catchment. This type of flood is often catastrophic, especially when the major rivers rise simultaneously and when rainfall floods are already leading to a reduced drainage capacity. Floods in general are beneficial for fisheries habitat connectivity, groundwater recharge, wetland augmentation, flushing of pollutants and in particular increase of soil fertility. On the other hand, the damage caused by floods can be considerable.

The coastal zone of Bangladesh will remain hazardous for coastal floods and the area will remain vulnerable to socio-economic setbacks, damage to and loss of lives and property in the foreseeable future. Cyclones and accompanying storm-surges will, with probably higher frequency, continue to develop in the Bay of Bengal, with floods characterized by possibly increasing water depths and velocities due to SLR and by longer duration and increased salinization. High river discharges and monsoon precipitation will continuously put an enormous pressure on the drainage capacity in this Delta area. Besides possible future changes in discharge regimes or rise of the sea level, the coastal zone will be under increasing pressure by socio-economic changes, with economic– and demographic developments as main drivers. Based on this, three principles for flood risk management form the basis for the Flood Risk management strategy:

- Supporting the economic development, without endangering the environment;
- Creating a climate-proof Bangladesh, making optimal use if its natural conditions;
- Leaving no one behind, building on resilience;
- These principles lead to three Flood Risk Strategies.

Strategy FR 1: Protecting Economic Strongholds and Critical Infrastructure

Supporting economic development implies that those areas that are essential for the economic growth of Bangladesh require a high flood protection standard. This is required to attract the investments that allow the economy to grow. Typical measures that can provide this level of protection include embankments, barriers, erosion control, and efficient drainage systems. Most of these measures are already in place, albeit at a basic level. In addition, adapted flood proof building is needed for key facilities such as hospitals, power stations, industrial plants and major communication networks between these facilities. The following indicative flood protection levels for these economic strongholds and vital infrastructure are proposed: 1/100 and 1/250 up to 2030; 1/250-1/1000 up to 2050, and 1/1000-1/2500 by 2100.

There are five sub-strategies. They are:

Sub-strategy FR 1.1: Develop and improve embankments, barriers and water control structures

Sub-strategy FR 1.2: Construct adaptive and flood-storm-surge proof building

Sub-strategy FR 1.3: Adopt spatial planning and flood hazard zoning

Sub-strategy FR 1.4: Extension of the flood warning lead time

Sub-strategy FR 1.5: Improvement of Drainage

These sub-strategies, including measures, are visualized in Figure 13.5.

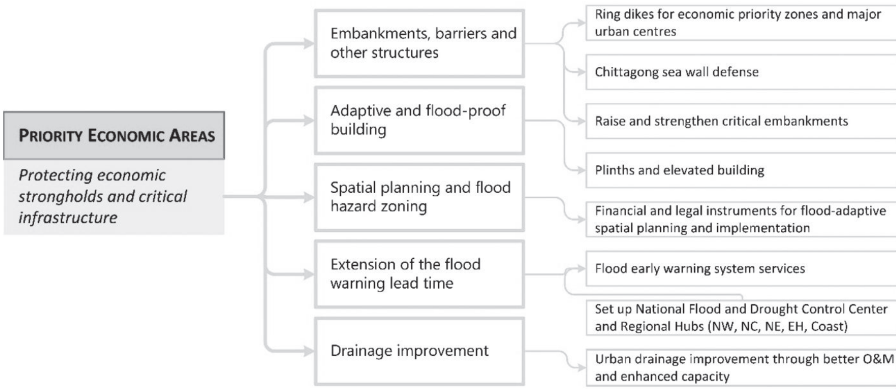


Figure 13.5: Overview Strategy Protecting Economic Strongholds and Critical Infrastructure

Strategy FR 2: Equipping the FCD Schemes for the Future

The country has already invested heavily in FCD development over the past 60 years, FCD schemes are in urgent need of maintenance and, in selected areas, remodeling to equip them for the future. Future designs need to take into account projections of climate– and hydrological change, sea level rise, as well changed land use, additional infrastructure and urbanization. Considering present climate change projections, up to 2030, the rapidly changing socio-economic conditions are important as well. Beyond 2030, depending on which scenario actually unfolds, climate change may have an ever-increasing impact. How the future unfolds is inherently uncertain and investing in measures that could be rapidly outdated due to changing conditions needs to be avoided. At the same time, over-dimensioning of structures — which later turn out to be unnecessary, lead to a waste of scarce resources. Flexible measures that are efficient under a range of boundary conditions are therefore the most attractive way forward. These are no-regret measures. This is where the Delta scenarios including climate change, sea level rise and socio-economic development, come into play to assess the robustness of different strategies and measures.

Regarding flood protection standards, this strategy includes differentiation which is foreseen between highly productive and diversified FCD schemes, that could develop into economic strongholds, and the agriculture based FCD schemes that are aimed primarily at securing food production and alleviating rural poverty. Cost-benefit analysis lies at the heart of such differentiation. Equipping FCD schemes for the future is also about improving operation and maintenance and giving ample attention to long term management. Participatory water management and enhanced private sector involvement, as well as equipping the users and managers of these FCD schemes with the skills and tools to effectively manage FCD schemes, are part and parcel of this strategy. There are five sub-strategies. They are:

Sub-strategy FR 2.1: Drainage improvement

Sub-strategy FR 2.2: Restoration, redesign and modification of embankments and structures.

Sub-strategy FR 2.3: Restoration of water bodies and connectivity

Sub-strategy FR 2.4: Improve operation & maintenance

Sub-strategy FR 2.5: River management, excavation and smart dredging.

These sub-strategies, including measures, are visualized in Figure 13.6 A distinction is made between measures that can or should be taken up by FCD managers and beneficiaries themselves (FCD Schemes– internal management) and for which capacity building and training are key ingredients; and measures that lie in the external environment and for which Government agencies are primarily responsible. Many legal and financial aspects are part of this group of measures.

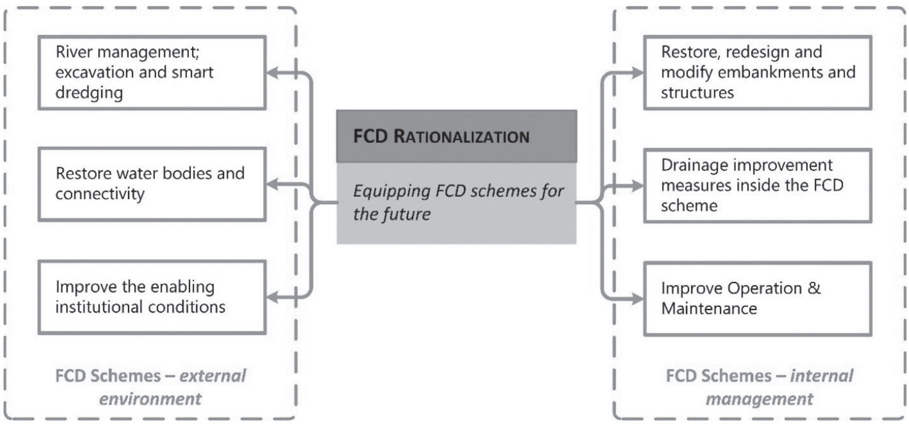


Figure 13.6: Strategy FR2: Equipping FCD Schemes for the Future

Strategy FR 3: Safeguarding Livelihoods of Vulnerable Communities

In addition to protecting economic strongholds, there is an obligation to provide safety and to support economic resilience of vulnerable regions and communities in the country. This is in line with the principle of "leaving no-one behind". This type of "protection" is not aimed at avoiding floods and creating a flood free Bangladesh for all. Given the current level of economic development, this is not feasible within the coming decades. Considering the extreme natural and socio-economic boundary conditions and inability to ensure adequate O&M of flood protection infrastructure in remote and poor areas, it is not a desirable goal in the medium term. Leaving no one behind merely means: (i) mitigating the most undesired effects of large and extreme floods; and (ii) enabling those who are affected by floods to recover quickly in the aftermath of the flood events.

Here the vulnerable communities primarily need attention. The flood management measures are a combination of reducing the impact of floods and developing economic measures that are relatively easy to implement, with low O&M requirements. Examples are forecasting and warning systems that penetrate deeply into the communities e.g., via mobile and digital social networks; and adaptive buildings, shelters, drainage and submersible embankments. There are seven sub-strategies; six are presented Figure 13.7.

Sub-strategy FR 3.1: Extension of early warning services into the communities

Sub-strategy FR 3.2: Extension and improvement of cyclone shelters

Sub-strategy FR 3.3: Flood and storm surge proofing of housing and critical services

Sub-strategy FR 3.4: Social safety net and recovery

Sub-strategy FR 3.5: Pilots for nature-based flood defenses

Sub-strategy FR 3.6: Improving drainage

Sub-strategy FR 3.7: Protection of chars and its population along with alternative livelihoods.

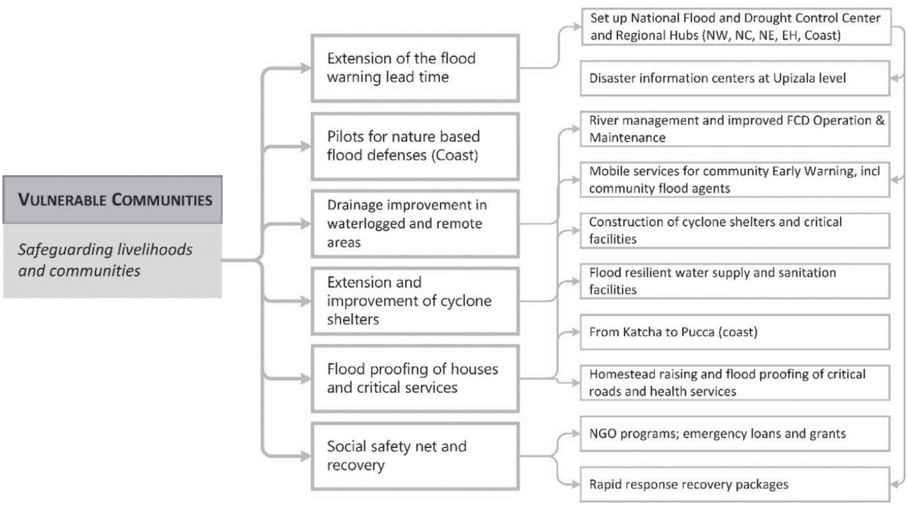


Figure 13.7: Strategy FR3: Safeguarding Livelihoods of Vulnerable Communities

The long-term perspective is shaped by elaborating two potential long-term strategies or development philosophies. The two long term potential strategies are called Optimized Water Control and Adaptation by Design. Both visions and associated strategies will never be implemented in their entirety. Each region will have a different mix and over time, when the water system has been developed to a sufficient extent, the vision will change, along with societal values and economic development. The two long term strategies should therefore be seen as cornerstones:

Both end visions and strategies have the variable hydrology and climate in mind, and are based on an understanding of the multiple uses and functions of the delta systems. To gain control, the country needs to ensure the right amount of water at the right time, and of the right quality. The difference between Adaptation by Design and Optimized Water Control is that a vision and strategy according to Adaptation by Design: (i) tries to avoid interventions where possible by looking for alternatives, but does not exclude interventions; (ii) focuses on local solutions and strengthening of local communities and governance; (iii) puts great efforts in cooperation and transboundary negotiations; (iv) uses natural processes where possible (Building with Nature); and (v) is based on differentiated flood zoning, rather than full embankment of the major rivers. Whereas, a vision and strategy according to Optimized Water Control: (i) focuses on interventions as soon as knowledge, institutional capacity and finance permits; (ii) provides a basic safety against floods for all, allowing regular floods to enter by controlled gates; and (iii) aims at being independent from India by means of its own barrages and flow diversion projects.

Pathways close to an Adaptation by Design strategy are more adaptive than strategies that adopt the Optimized Water Control policy. An illustrative example is riverbank stabilization and development of flood protection embankments, measures in line with the strategy. Once this set of measures has been implemented and an area is protected against floods, it becomes difficult to remove the protection in favor of resilience or ecological values. People will have invested in economic activity that is not vulnerable to flooding because society relies on the protection or stabilization provided.

Short Term Preferred Strategies and Interventions

For the short-term, the preferred strategy includes risk-informed rationalization of all the current FCD(I) projects based on current and future needs in a programmatic way. This includes the assessment of differentiated design protection parameters, (automated) drainage and irrigation capacity and potential pumping capacity. Furthermore, in the improvement or development of protection to investigate the potential for low-maintenance solutions, such as "Building-with-Nature", should be investigated. Embankments in areas with high erosion risk (throughout the coastal zone), should be sufficiently protected with local hard or soft stabilization solutions.

In the preferred strategy, polders in areas that are considered geo-physically stable (e.g., inland polders in the southwest region or along the Chittagong coast) and have dominant agricultural or aqua-cultural use (also in the foreseeable future), are sustained at a basic level of protection (e.g., ~1:25 year return period incl. climate change). This ensures a productive environment for the rural population under normal conditions. The needed and feasible differentiated level of protection is to be based on a risk-informed cost-benefit analysis, including aspects of income distribution and potential future change (e.g., economic shifts in development: seaports, SEZs, infrastructure). To mitigate impacts of extreme floods (with a lower probability than protection level), additional flood risk prevention measures, like supporting living on the highest parts of the polder, and policy interventions to decrease vulnerability of the (poor) population, such as income diversification, social safety nets, as well as a coastal-wide revolving fund program ("From Kutcha to Pucca houses") should be investigated. In addition, flood risk preparedness, needs continuous attention, by ensuring enough modern cyclone shelters, coordinated flood patrolling procedures, as well as investment in effective Flood Early Warning Systems, e.g., with localized flood impact forecasting.

For coastal urban areas or areas of national economic significance (e.g., seaports and infrastructure, e.g., the port of Payra, or economic zones) now or in the foreseeable future, higher levels of protection are preferred (e.g., 1:100-1:250 year incl. climate change). This should be defined and maintained based on a comprehensive optimized cost-benefit analysis. It is always no-regret to invest in the highest valued assets (incl. population) at the local highest elevations, as well as to optimize flood proofing of infrastructure buffer zones, and to promote preparedness measures (EWS and cyclone shelters). The development of Mongla port is a specific issue, mainly because of the potential environmental consequences. The protection level(s) of the Chittagong floodplain need to be determined based on the same optimized cost-benefit assessment methods.

The current waterlogging issues in the polders of the Western Ganges tidal floodplain (e.g., Khulna, Sathkira region) and Noakhali mainland need attention. An extensive tidal river management program needs to be started and assessed for its feasibility both on a regional scale and polder by polder. This assessment may best be related to a full rationalization program regarding the functioning of existing FCD(I) projects in Bangladesh. Ideally, when new large-scale interventions are planned (e.g., land reclamations), its impact on the drainage capacity of the whole system (also upstream) needs to be investigated. The drainage congestion problems in the Noakhali mainland area may be best mitigated by developing an integrated drainage network and by stimulating sediment supply from the Lower Meghna River. A comprehensive drainage and sediment study is a pre-requisite to such a program.

After 2050, depending on the then occurring climate and economic conditions, the Government of Bangladesh may choose for further continuation of the strategy up to 2050 or may decide to invest in large storm-surge barriers or cyclonic storm surge proof (climate resilient) embankments in the South Eastern river mouths (Baleswar, Tetulia river), as well as Chittagong harbor (Karnaphuli river). The most effective way of decreasing total coastal flood risk further, is to support (by large investments in infrastructure) new developments on the highest parts of the country (e.g., Barind or Madhupur tract). Investment in nation-wide flood hazard zoning maps, based on geo-physical characteristics and modelled floods, will be of particularly importance here.

The following short-term interventions have been formulated in the framework of the three Flood Risk Strategies discussed above.

Diminish Drainage Congestion

The drainage congestion in the coastal zone is a big issue (because of the reasons mentioned in section 13.1.2). Increasing the drainage capacity will reduce the flood risk. The measures or project list contains amongst others:

1. Restoration of rural rivers/canals and livelihood improvement in exposed coastal districts;
2. Restoration of rural rivers/canals and livelihood improvement in interior coastal districts;
3. Study on Impact Assessment and Strategic Directions on Tidal River Management (TRM);
4. Improved drainage problem in Bhabadha area;
5. TRM in 7 polders near Khulna;
6. Integrated management of drainage congestion for Greater Noakhali;
7. Char Development and Settlement Project-V;
8. Sureswar flood control, drainage and irrigation project;
9. Suitability study to potential largescale pumping to alleviate drainage congestion.

Flood Risk Protection

The flood risk is very high in the coastal zone and it becomes disastrous when flood coincides with a storm surge. A number of measures are needed to reduce the flood risk and save lives. Some of these measures are:

1. Develop CEIP strategy, including risk-informed and system-based protection levels based on proper CBA (also poverty bias) for future change (incl. yet unprotected areas).
2. Develop multipurpose flood embankment on the right bank of the Ganges, the Padma and the Meghna rivers from Mathabhanga off-take at Jalangi to Muladi.
3. Construct the Cox's Bazar Marine Drive Road (multipurpose embankment).
4. Enhance regional connectivity with Myanmar and China, including attention for disaster management, tourism.
5. Study to identify preferred low-maintenance solutions in protection for the design manual of BWDB.

6. Study the morphological dynamics of Meghna Estuary for sustainable char development.
7. Implement the Integrated land reclamation project of Hatiya-Dhamar Char-Nijhum Dwip.
8. Implement the Urirchar-Noakhali Cross dam project.
9. Construct 11 nos. cross-dams in the Meghna, Tetulia estuary, Districts of Patuakhali and Bhola.

x. Develop a flood-free and cyclone robust seaport and SEZ zones.
xi. Stabilize THE right bank of THE Lower Meghna River along eastern shore IN Bhola.
xii. Study on possible impacts of buildINg megastructures IN THE coastal estuary (salINity barriers/storm surge barriers) under future change.

Flood Risk Prevention

For flood risk prevention, it is necessary to make the infrastructures sustainable to flooding. Proposed measures are:

1. Continuous develop flood hazard and risk maps for flood/hazard zoning.
2. Undertake a feasibility study for revolving fund subsidiary "Kutcha to Pucca houses".
3. Prepare a plan to increase the density of (secondary and tertiary) all-weather roads and bridges network.
4. Develop flood-proof roads along the coast of Cox's Bazar, Chittagong, Noakhali, Barisal.

Flood Risk Preparedness

To reduce the fatalities due to floods, preparedness against flood and its timely implementation is necessary. Related projects are:

1. Establish hazard control center(s), improve effectiveness (lead time) of national Early Warning System (EWS), as well as localized warning (hazard impact modelling).
2. Update cyclone shelter preparatory study of 1998, and construct and maintain multi-purpose cyclone and flood shelters.

13.2.2 Freshwater Strategy: Balancing Water Supply and Demand for Sustainable Growth

As National Strategy, the Freshwater Strategy builds on the concept of Hotspot areas (see Chapter 12). Of particular importance are the Rivers and Estuary, Barind region, Coastal Zone and Urban Areas, where issues of drought, freshwater availability and water quality are a growing concern. In the Coastal Zone, salinization of surface and groundwater, as well as aquifer contamination with arsenic are key challenges.

Freshwater resources are particularly vital for the agriculture sector, which includes the crop sector, livestock, fisheries and forestry sub-sectors. At national level, agriculture provides employment to approximately 70% of the population and contributes some 19.5% to the GDP. Water resources are also important for the growing transport sector (see section 13.2.4). The significance of water resources for the industry sector, an important engine for the country's growth over the last 10 to 20 years, is growing rapidly. Whereas water demand is still low compared to the agriculture sector, industrial use is expected to grow by 440% by 2050. Water resources are particularly important for the textile and leather industries, both in terms of consumptive needs and in view of the pollution pressures caused.

Water quality is a growing concern for the country, with 32 rivers, located predominantly in the urbanized areas and divisional capitals, and many of the wetlands at serious environmental risk due to pollution, encroachment, and disconnection between wetlands and the river system. The latter is particularly relevant for the North West and North Central hydrological region. Bio-chemical pollution is specially an issue in the two largest urban agglomerations Dhaka and Chittagong and to a lessor, but growing, extent in many of the District capitals and industrializing areas.

The Freshwater Strategy focuses on both the availability and quality of water. The Coastal Zone (the South West hydrological region in particular), and to a certain extent the Chittagong Hill Tracts), drought is mostly related to water needs for agriculture and water supply; in other areas, drought is a growing issue for industry, navigation and environment. Water quality is a key issue in the Urban Areas and Coastal Zone, with respect to both bio-chemical pollution, salinity and arsenic contamination.

The Freshwater Strategy not only focuses on solving the issues of today, projected into the future, but also with an end vision in mind and back casting towards the present. These are amalgamated into the preferred strategy. By focusing on both the short and the long term, the BDP2100 aims to overcome the well-known pitfall that "the solutions of today become the problems of tomorrow".

The preferred strategy for coastal freshwater aims to improve living conditions, sustain agricultural and aqua-cultural production, as well maintain environmental sustainability. For the short-term, the preferred strategy includes revitalizing surface water supply sources from the Ganges as much as possible. For the coast, the construction of the Ganges barrage to restore the freshwater flow through the Gorai and other rivers would be advantageous, certainly with respect to availability of drinking water and fight against salinization in the Sundarbans. But an additional study is needed to ensure a long-term sustainable situation at the regional level. Current FCD(I) infrastructure needs to be modernized, as insufficient maintenance and changing external conditions have led to a substantial degree of malfunctioning. A main aspect to be solved is management (Operations & Maintenance), which needs innovative forms of institutions.

Year-round availability of freshwater for different users is currently specifically a problem in the South Western region, as freshwater flow and precipitation excess in the Lower Meghna dependent area is still sufficient. Overall, irrigated crops in the dry seasons are the largest consumers of freshwater throughout the coastal zone. Measures to relieve pressure on these demands are recommended. Drought– and salinity early warning systems with localized impact and water pricing are considered no-regret. Competing main uses of freshwater in the coastal zone are agriculture, natural ecosystems (e.g., wetlands, *beel*s, fisheries and the Sundarbans) as well as navigation for regional waterway transport. For ecosystems, it is recommended to improve the connectivity between wetlands and floodplains and restore the natural capacities of *beel*s and natural waterbodies where possible. The unique and largest mangrove forest, the Sundarbans, need to be protected by (inter-)national laws and programs and should be managed to maintain its unequalled characteristics. Some polders on the northern border of the Sundarbans should be investigated to identify possibilities to restore the area to historical proportions, which will improve environmental sustainability, as well as the natural wave attenuation capacities of mangroves in times of storm surges. In this sense, it is also fundamental to monitor and understand the impact of land accretion for the functioning of the Sundarbans, also in terms of flood hazard attenuation.

The Freshwater Strategy consists of two distinct but related strategies: for water availability and for water quality. The two objectives are detailed into sub-strategies and measures. For each strategy, attention is paid to three aspects: infrastructure, institutions and innovation.

Strategy FW 1: Ensure Water Availability by Balancing Supply and Demand for Sustainable and Inclusive Growth

The freshwater strategy is aimed to ensure water availability by balancing supply and demand for sustainable and inclusive growth. As described above, increased droughts and water shortages for different socio-economic sectors are expected in the future and if one continues with the "business as usual" practices, these constraints will hamper the sustainable growth. The cross-boundary issues are important here. In the sections below, first the sub-strategies are summed up. Thereafter, the main measures or interventions are presented.

Sub-strategy FW 1.1: Supply management and additional irrigation including strong dialogue and prospects for river basin development for cross-boundary rivers

Sub-strategy FW 1.2: Demand management and efficient water use

Sub-strategy FW 1.3: Enhancement of freshwater flows in urban and rural rivers

Sub-strategy FW 1.4: Resource planning and environment

Sub-strategy FW 1.5: Ensuring safe water to sustainable drinking water and sanitation.

Strategy FW 2: Maintaining Water Quality for Health, Livelihoods and Ecosystems

This strategy is based on the second objective of water quality. Water quality is a growing concern for the country, with many rivers and wetlands at serious environmental risk. To ensure healthy lives, livelihood and ecosystem of Bangladesh, the quality of water needs to be maintained according to rules and regulation. This strategy has one sub-strategy, focusing on pollution and treatment. This sub-strategy involves both protection of environmentally valuable and sensitive areas and the prevention of pollution by enhanced treatment. Industrial facilities and farmers upstream of the coastal zone, need to follow strict regulations in their treatment of effluents and use of fertilizers in order to protect the surface water.

The following interventions have been identified:

Supply Management and Additional Irrigation

The identified interventions are:

1. Construction of Ganges barrage and ancillary works;
2. Study on possible impacts of building megastructures in the coastal estuary (salinity barriers/storm surge barriers) under future change;
3. Restoration study of regional tidal rivers;
4. Improve FCD(I) project database (incl. performance indicators) and setup monitoring programs (physical, topographical, socio-economic, land-use etc.);
5. O&M of FCD(I) projects;
6. Rehabilitation of Polder 36/1 project;
7. Rehabilitation of Water Management Infrastructure in Bhola district;
8. Rationalization program of 18 projects;
9. Developing Climate Smart Integrated Coastal Resource Database (CSICRD);

x. West Gopalganj Integrated Water Management Project.

Demand Management and Efficient Water Use

The proposed measures are:

1. Increasing cropping intensity in the southern region of Bangladesh;
2. Southern agricultural improvement project;

3. Exploration of the production potential of saline soils of Bangladesh;
4. Drought and salinity EWS development with localized warning (plus agro-meteorological services).

Resource, Planning, Protection and Environment; Restoring Water and Ecosystems

Proper planning procedures of natural resources need to be developed and implemented. These are required to ensure proper restoration of water resources (*beel*s and *baor*s) and as well as the ecosystems that depend on these resources.

13.2.3 Drinking Water Supply

The issue of increasing dry season salinization of the surface water in the western Ganges tidal floodplain is an important component of the freshwater problems in the coastal zone. Improving the fresh surface water situation in the coastal zone will improve the situation for many sectors in need for freshwater. This water is fundamental for *boro* rice irrigation (dry season), industrial demands, domestic use (drinking water supply) and last but not least for maintaining biodiversity in the Sundarbans.

Some of the measures proposed here are similar to the above indicated measures to diminish drainage congestion. One of the main questions here is to what extent Bangladesh needs or wants to sustain rice agriculture as main land use and income activity for the rural population in the coastal zone. Several measures are focused on restoring freshwater conditions fully (if possible), others are focused on adapting to (new) geophysical conditions.

For decades the coastal zone has been known for its harsh water supply conditions (salinity, high iron and arsenic content). While freshwater supply for municipal and agricultural use pose a challenge today, the expected developments (increasing population and economic development will increase demand, climate change is apprehended to aggravate the problems) will only increase the challenge.

In the coastal zone there is a transition from freshwater (inland) to saltwater (sea). The saltwater will tend to reach further inland with reduced river run off and with increased sea level rise. Large populations in the coastal zone have no access to freshwater from rivers. The alternative option for fresh surface water is local impoundment in ponds. Pond water supply systems, including Pond Sand Filters (PSF's) have generally proved not to be very effective. The public is reluctant to trust the PSF produced water, and O&M practice of PSF's is generally poor. In coastal areas rainwater harvesting method is used to store water for domestic usage. Many people are not aware of the contamination of the stored water. Many of the households use rainwater without any purification. Usually rainwater is purified by alum mixing and boiling to remove various harmful bacteria and polluting contaminants. New available techniques may be implemented for the improvement of rainwater harvesting systems.

Shallow groundwater aquifers are available as a matter of principle in many areas of the coastal zone. However, the deeper groundwater is brackish or saline (with freshwater being available at, again, greater depths). There are three main paths of salinization in the coastal aquifer: Intrusion of saline water in the coastal groundwater, with the sea as the source of saline water, that could be accelerated either by sea level rise and/or falling ground water level.

Downward vertical movement of saline surface water to the aquifer. This saline surface water could be brought inland by storm surges or transgression of the coast.

Migration of Pre-Existing Pockets of Saline Water in the Subsurface

It can be seen that the fresh water-saline water interface lies about 50 to 75 km inland in the western most part of the coastal region but swings sharply to the south and lies approximately at the coastline over most of the rest of the area. The occurrence of brackish and saline water does not follow any regular pattern spatially or vertically. Over abstraction of shallow groundwater tends to draw the saline water into the shallow aquifer rendering a fast deterioration of its quality. In many locations, salinization of shallow groundwater (first and second aquifer) has occurred. Due to salinity the shallow groundwater is generally not suitable for domestic uses. Flushing of saline water takes place in some isolated pockets to enable a limited domestic use of fresh water in the shallow aquifer. The combination of over abstraction and saltwater intrusion from the sea is apprehended to deteriorate when sea level is rising.

There is no easy solution to the (future) coastal water supply challenges. In further BDP2100 hot spot planning activities, options will be explored and further developed. Solutions may include:

i. **Seawater desalination**: costly and complex;
ii. **Rainwater harvesting**: typically for low per capita usage. Extended dry spells will strain capabilities;
iii. **Piped water supply**: difficult to find suitable sources;
iv. **Surface water retention: larger lakes: irrigation competition, land use issue; ponds**: land use issue, water quality;
v. **Aquifer recharge**: through ponds, land use; through injection, which is complicated; capacity constraint, relative to abstraction.

For long term, sustainable solutions, planning for construction of disaster resilient houses in clusters on raised grounds, and transportation infrastructure to facilitate communication, along with individual or community type drinking water and sanitation infrastructures would be needed.

In the coastal zone, salinity of water and damage of water infrastructures due to cyclone, tidal surge and inundation of lowlands are major problems for supply of drinking water. Climate change related extreme events such as cyclones will damage water supply infrastructure while sea level rise and salinity intrusion will deteriorate water quality in the coastal zone. Rapid growth of urban population poses a serious challenge for the urban institutions responsible for the supply of water. Piped water supply is available only in urban areas but the coverage reaches only about 30% of the urban population. Consequently, people have to depend on shallow hand pumps connected to each household for drinking water. In most of the city corporations and *pourashava*s, a significant proportion of households who are connected to piped water also rely on hand pumps for drinking water as the supply of piped water is intermittent and unreliable. The poor people especially the slum dwellers are the worst sufferers.

Groundwater is the main source of water supply accounting for about 90% of the total supply of drinking water in the country. Most sources of water supply are tube wells with hand pumps and motorized pumps sunk by households, water utilities and local governments. Over abstraction of groundwater is making tube wells vulnerable to falling water tables. The water levels of deep aquifers are dropping in many towns, especially in larger industrial areas. A more integrated approach to water supply management is needed to better balance the gap between supply and demand through demand management, use of alternative water sources and use of soft measures to improve treatment.

13.2.4 Safe and Reliable Waterway Transport

The inland water transport (IWT) sector supports the livelihoods of some 6.4 million people and contributes 30% of overall freight transport output and 20% of passenger travel. The IWT sector is growing rapidly, with cargo traffic increasing from 20 to 30 million tons annually from 1994 to 2005. Important interventions would be to develop and maintain main navigation channels for large vessels: Chittagong-Dhaka-Ashuganj regional corridor improvement project (BIWTA) and implement national navigation master plan. From environmental point of view, Mongla port is poorly located and should be abandoned, or guaranteed to be not destructive for the vulnerable ecosystem of the Sundarbans. The tidal rivers are part of an extensive network for transport of goods and people over water. Several measures are to be taken.

On the one hand navigation possibilities have to be improved by excavation/dredging and cargo-facilities have to be adapted. On the other hand, measures to optimize alternative ways of transport (specifically explore multi-model opportunities) should be introduced. This will decrease pressure on the yet exhaustive use of the water system as a whole.

13.2.5 Adaptive Strategies for Waterlogging and Salinization

Where uncertainty is prevailing, adaptation or strategic pathways help in understanding, in scheduling measures and in developing optimal combinations for measures to meet the policy goals. The Delta-scenarios do not predict one single future; rather they describe different plausible stories of possible future developments. The scenarios have been developed to identify bottlenecks arising out of uncertain future developments and represent "extreme edges" of possible outcomes. Measures that are affected strongly in terms of their effectiveness by external conditions (climate, economic development, technology — innovation) may require further studies or can be delayed until actual conditions become apparent. Other measures, such as improved provision of safe drinking water and wastewater treatment for large urban centers, are considered basic measures which can and should be taken, dependent on each scenario. Logically, the degree of uncertainty is very high for the timeframe beyond 2050, moderate to high between 2030 and 2050 and moderate up to 2030. As can be observed from the scenario development, climate change is but one of the uncertainties, with socio-economic and upstream developments playing a significant role as well. Against the background of the potential strategies developed above, a number of pathways have been developed. It is also logical that for the freshwater strategy, the key uncertainty is related to water availability.

Waterlogging — Diminish Drainage Congestion

As discussed above, several polders and areas in the western part of the Ganges Tidal Plain experience persistent waterlogging issues: rainwater cannot adequately be drained. An adaptation pathway is created for the set of solutions proposed before:

1. **Ganges Barrage:** To effectively improve drainage capacity of peripheral rivers in the dry season. It is estimated that this intervention may be effective for 30 years under the most favorable future scenario. In the least favorable situation, it is estimated the barrage will only be effective for 20 years.
2. **Maintenance Dredging Gorai (Iterative):** Being the main freshwater source of the area, this will improve drainage conditions of the peripheral rivers for a short time (2-3 year), unless it is executed periodically. Maintenance dredging is a no-regret measure and supports every other proposed measure. It is however not sustainable for the long-term and not effective to solve the (expected) waterlogging in different future scenarios on its own.
3. **TRM for 10 Years:** This involves cutting embankments at strategic locations in order to bring polders for a certain period (about 10 years) under normal tidal influence. Sediment will be supplied to the lowest locations, and tides will scour the peripheral rivers, improving the drainage capacity of the water system. This measure can have large socio-economic consequences for the current population, and affected households have to be compensated. It is estimated that TRM at strategic locations in the coastal zone may improve

drainage capacity for 20 years in the most favorable future and 15 years in the least favorable. TRM can be applied in a cyclic way.

4. **Pump and Drainage Improvement:** Waterlogging within drainage-controlled areas (e.g., polders) can be diminished by small and large mechanical pumping. This intervention includes improvement and reparation of the current drainage infrastructure (e.g., *khal*s, sluices). These measures will improve the situation for several years (10 — 20 years in favorable conditions, depending on pumping capacity, 7-15 years in the least favorable future conditions).
5. **Revitalize Regional Rivers or Provide Channels:** Several regional rivers have died over the last decades. a study should be commenced to investigate potential revitalization projects of the regional rivers and/or providing supply channels (water and/or sediment) from the Ganges tidal floodplain east or Lower Meghna estuary. This measure comprises a huge intervention in the water system of the Ganges tidal floodplain, but first estimates show effectiveness for more than 60 years in the most favorable future conditions to more than 40 years in the least favorable.
6. **Adapt Land Use:** As is currently observed in the area and what may be considered as autonomous adaptation. Many areas are increasingly exploited for aquaculture, sometimes in rotation with rice and fish production (see also Chapter 5). It, however, requires a minimum water quality level (e.g., salt level, biotic deterioration), that can be managed with adequate water infrastructure. It further changes the polder configuration regarding land management (larger plots, less people profit), and sometimes lead to conflicts between traditional farmers, fisherman and aquaculture farmers. This autonomous adaptation is considered effective for the long-term.
7. **De-Polderize:** This process is often seen as the last resort, when living conditions have deteriorated below an acceptable minimum. This measure can also be used in a strategic sense, as it may enhance drainage capacity in its neighborhood or enhances protection/restoration of environmentally sensitive areas (e.g., Sundarbans). as population density in Bangladesh is generally high, this measure may be very costly (in social terms) because of the necessary resettlement of the current population. When considered, however, as part of an integral strategy for the coastal zone, it may be relevant with a view on national interests. This measure is also considered to be effective for the longer-term.

13.2.6 Reclaiming New Land in the Coastal Zone

The Ganges-Brahmaputra-Meghna (GBM) system is carrying a huge volume of sediment to the Bay of Bengal through several estuaries; among them, the Meghna Estuary is the biggest. Estuaries are the place where sweet water mixes with saline water. It is observed that the areas of accretion and erosion were 1,810 sq.km and 1,205 sq.km respectively during 1973-2015 in the Meghna Estuary. Net accretion area is about 605 sq. km during this 42-year period. Accretion was more than that of erosion in the Meghna Estuaries areas (see also Chapter 2). It is assumed that land development may be possible in the Meghna Estuaries and in the coastal zone.

Increasing land availability through accretion/land reclamation in the Meghna Estuary, is the main purpose of this strategy. There are some land reclamation interventions in the estuary area that are developed by the CDSP project. The strategy aims at building further on the successes of different land reclamation projects in the past, full exploitation of the potential area, by accelerating natural sedimentation processes in the Meghna Estuary at strategic locations. Where natural process may take 60 to 80 years to build the new land, human interventions may accelerate the process to 35 years. Through this strategy, an enormous industrial potential can be realized on the new land and its direct surroundings like economic zones, tidal and wave energy production, wind energy parks, new deep sea-port development, exclusive housing as well as tourist developments. And new land will also be made available for distribution among farmers to support their livelihood and to take steps toward greater food security. Moreover, the new land may decrease the frequency and severity of the cyclone induced storm surges. But for unlocking this development potential, the flood risk needs to be reduced significantly, which is a huge challenge. This challenge may be dealt with through a combination of land filling up to 20 m above sea level for the most critical infrastructure and assets by using the sediment from the Meghna Estuary, and through building dykes with mangrove belts to reduce wave run up.

Accretion and optimum use of land would significantly contribute to the regional economy and wellbeing of the local people. Accelerating the natural accretion processes with cross dams and other infrastructure in this highly dynamic environment, may offer a large piece of newly gained land, free to be developed in the preferred way. All accreted and reclaimed land should be put to value added used particularly for urban and industrial needs with necessary infrastructure like dikes, high quality road, rail, water transport mode connection, recreational area with adequate power and energy supply. An ample attention will be needed for mitigation or adaptation to wind or storm surge hazard by elevating platforms as well as the freshwater availability issues.

There are three sub-strategies within this strategy that could be implemented in two phases. The strategies in the first phase are —

Conduct Research on Morphological Behavior of the Meghna Estuary to Assess the Effect and Potential of Land Reclamation

Extensive research needs to be conducted to gather knowledge about the process of land reclamation and to realize the potential of further development and artificial interventions for acceleration process.

Accelerate Land Reclamation Process in the Meghna Estuary

New land may be reclaimed over a large area (Figure 13.8) given the urgent need for space and land, following an accelerated process by constructing cross dams presented below or/and some other methods:

a. Hatiya-Nijhum Dwip cross dam;
b. Hatiya-Damar Char cross dam;
c. Hatiya-Moulavir Char-Dhal Char-Char Parvez cross dam;
d. Sandwip-Urir Char-Noakhali cross dam;
e. Sandwip-Urir Char-Noakhali cross dam;
f. Char Rustam-Char Haldor cross dam;
g. Char Haldor-Char Burhan cross dam;
h. Char Burhan-Bhola cross dam;
i. Char Kukri Mukri-Char Alcha cross dam;
j. Char Montaz-Char Tapashi cross dam;
k. Char Montaz- Andar char cross dam;
l. Bhola-Kukri Mukri cross dam;
m. Bara Baisda-Char Halim cross dam;
n. Char Halim-Choto Baisda cross dam;
o. Rangabali-Choto Baisda cross dam;
p. Choto Baisda-Char Biswas cross dam;
q. Char Kajal-Char Biswas cross dam;
r. Char Kajal (Shibar Char)-North Char cross dam;
s. North Char (Char Nilkamal)-Kasher Char cross dam;
t. Rangabali-Char Kashem cross dam.

Protect, Develop and Zoning of the Reclaimed Land

Land zoning, development and protection of these reclaimed land needs to be taken up, i.e., the next CDSP phase even in a larger context.

13.3 UTILIZING THE BLUE ECONOMY

Bangladesh has received entitlement on 118,813 sq.km in the Bay of Bengal comprising her territorial sea, Exclusive Economic Zone (EEZ) and Continental shelf at the end of the final settlement of maritime border disputes with neighboring states Myanmar and India in 2012 and 2014 respectively. The shallow shelf sea constitutes about 55%, the rest (45%) lying in deeper waters (see also Figure 13.1). Territorial waters are in BDP2100 considered as a new “development space” in

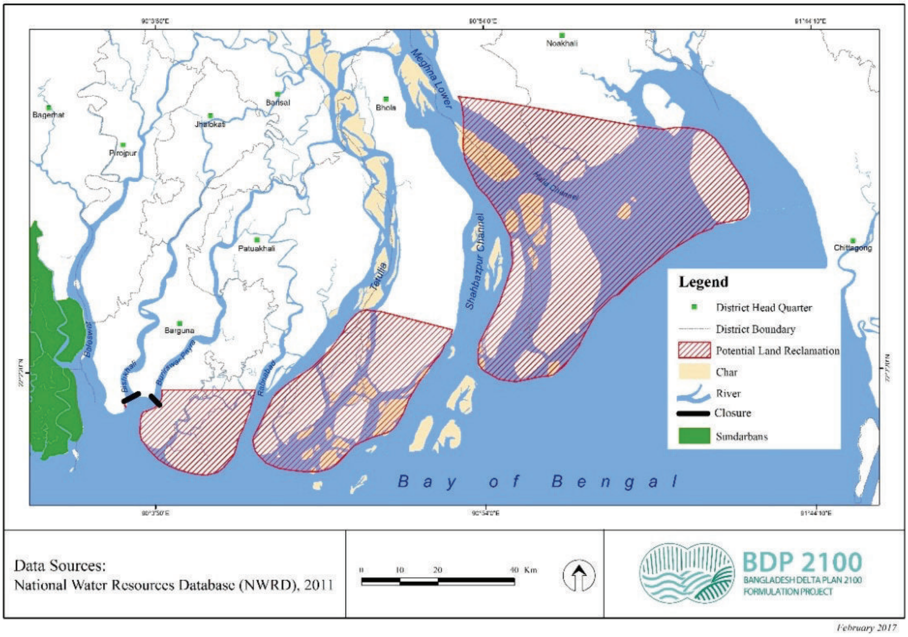


Figure 13.8: Potential Land Reclamation in the Coast

Bangladesh. The development of the "blue economy", therefore, forms an integral part of the BDP2100 for both economic growth and food security.

The blue economy comprises of activities that directly or indirectly take place in the seas, oceans and coasts using oceanic resources and eventually contributing to sustainable, inclusive economic growth, employment, well-being, while preserving the health of the ocean. It includes activities such as exploration and development of marine resources, appropriate use of ocean and coastal space, use of ocean products, provision of goods and services to support ocean activities and protection of ocean environment. The blue economy approach emphasizes that ideas, principles and norms of blue economy lend are significantly in line with eradication of poverty, contribution to food and nutrition security, mitigation and adaptation of climate change and generation of sustainable and inclusive livelihoods. However, making a transition to the blue economy would entail fundamental and systemic changes in their policy-regulatory-management-governance framework(s) and identification of various maritime economic functions.

The Government of Bangladesh, through a gazette notification dated 22 October 2014, has constituted a 25-member "Coordination Committee to tap marine resources and its proper management". Recently, Energy & Mineral Resources Division of the Ministry of Power, Energy & Mineral Resources has been entrusted with the coordination. A "Blue Economy Cell" has been established within the Energy & Mineral Resources Division, that appointed a Director General of the Cell. To create and maintain prosperous and sustainable blue economy bases, the following strategies may be adopted:

- Enhance coastal shipping fleet and infrastructural capability including port facilities.
- Maintain existing (e.g., ship building) and develop new maritime industries.
- Enhance environmental ship recycling.
- Undertake a stock survey of marine fisheries.
- Develop and grow shallow– and deep-sea fishing with technology based fishing in and beyond the EEZ.
- Develop marine aquaculture and permaculture.
- Protect and conserve fish biodiversity.
- Develop ecotourism and marine cruises.
- Develop a long-term plan for continuous land reclamations; construct cross dams to reclaim land.
- Develop a strong renewable energy sector using ocean and atmosphere forces.
- Develop a strong human resources base for domestic utilization and export to foreign job markets.
- Build a solid science, research and education base.
- Establish a base for coordinating developments in blue economy.
- Promote private sector participation.

13.4 BDP2100 INPUT ON THE COASTAL ZONE IN THE FIVE-YEAR PLANNING CYCLE

The strategies and measures developed under BDP2100 need to be embedded and mainstreamed in the governance systems of the Government of Bangladesh. This takes place by selection and prioritization of measures and projects in the Five-Year Planning cycle and yearly budget allocation. Regarding the coastal zone, input to the 8th Five Year Plan (2021-2025) will be as BDP2100 Implementation Program 4, Coastal Zone: Safe and Resilient Coast. This focuses on Integrated Coastal Zone Management and Polder Rationalization. The following investment projects are relevant in this respect:

- **West Gopalganj Integrated Water Management Project:** Protect the West-Gopalganj area against flash floods and increase agricultural production through improved drainage– and irrigation capacity, implementing flood control measures and developing an integrated water management plan for the area.
- **Improved drainage in the Bhabadha area:** Reduce drainage congestion and floods through several river management interventions; rehabilitate the

Bhabadha regulator to increase drainage capacity; construct an embankment along the river; involve the community in the project.

- **Development of Water Management Infrastructure, Bhola Island:** Protect a particular area from floods, storm surges, salinity and erosion due to sea level rise; develop an Erosion Early Warning System for Bhola District.
- **Char Development and Settlement Project V:** Protect the inhabitants of newly accreted chars from erosion, floods and surges, and ultimately reduce poverty and hunger from people living there.
- **Program for Implementation of Rationalized Water Related Interventions in Gumti-Muhuri Basin:** Rationalize water resources management by improving infrastructure through modernization of existing water infrastructure with institutionalized participatory schemes cycle management process and ADM principles.
- **Program for Implementation of Rationalized Water Related Interventions in Gorai-Passur Basin:** Manage the water resources in an integrated, holistic way; rationalize water resources management by modernizing existing water infrastructures with institutionalized participatory schemes cycle management process and ADM principles.
- **Rationalization of Polders in Baleswar-Tentulia Basin:** Reduce loss of assets, crops and livestock from cyclone and storm surges; reducing saltwater intrusion in the polders; ensure freshwater flow in the rivers and canals; reduce agricultural production loss by protecting the lands from erosion.
- **Rationalization of Polders in Gorai-Passur Basin:** Reduce the loss of assets, crops and livestock; reduce vulnerability loss; reduce saltwater intrusion; increase agricultural production; improve drainage congestion situation; improve institutional setting.
- **Related Interventions in Baleswar-Tentulia Basin:** Reduce loss of assets, crops and livestock from cyclone and storm surges; reduce saltwater intrusion in the polders; ensuring freshwater flow in the rivers and canals; reduce agricultural production loss by protecting the lands from erosion.
- **Rationalization of Polders in Gumti-Muhuri Basin:** Reduce the loss of assets, crops and livestock; reduce saltwater intrusion into the polders; reduce saltwater intrusion; increase agricultural production.
- **Rehabilitation of Water Management Infrastructure in Bhola District:** Protect the citizens of Bhola against flooding, salinity and loss of land due to sea level rising; increase river flows and erosion; increase strength of seasonal typhoons.

- **Southern Agricultural Improvement Project (SAIP):** Increase agricultural productivity through better management and utilization of land and water resources, and promotion of climate smart technology in the southern region of Bangladesh.

13.5 CONCLUSION

The identification as one of the six Hotspots in BDP2100 is a clear indication of the significance of the Plan for the coastal zone. The Plan is larded with coastal issues; in the framework of this chapter only the most important ones could be highlighted. The Plan recognizes the challenges and potential of the zone. It provides strategies for major issues such as floods and availability and quality of fresh water. For each strategy, sub-strategies have been, followed by a series of concrete interventions. Sub-strategies with particular relevance for the coastal zone are, among others, development and improvement of embankments, drainage improvement, restoration of waterbodies, improvement of O&M, flood and storm surge proofing of buildings and houses, expansion of the number of cyclone shelters and enhancement of early-warning systems. Promising possibilities of the further development of the coast are found in the chances that the "blue economy" offers and the reclamation of new land.

It is important that the proposed prioritized projects and programs are taken up in the 8th Five Year Plan and in the subsequent annual budget cycles, i.e., inclusion in the Annual Development Programs and that key knowledge gaps such as the impacts on climate change, morphology, and crop diversification are taken up. For the central part of the coastal zone, the focus of this book, the interventions to accelerate land accretion, the rehabilitation of water management infrastructure (or instance on Bhola island), the continuation of the Char Development and Settlement Project in a new phase and research on the morphological behavior in the Meghna Estuary are of particular interest in the short– to medium-term.

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Chapter 14

Conclusion: Taking Stock and Looking Forward

Koen de Wilde

14.1 INTRODUCTION

This concluding chapter takes stock of the developments and situation in the Ganges-Brahmaputra-Meghna estuary by reviewing the three themes or story lines in the book, as identified at the end of Chapter 1. The first one is the chronological line, focusing on natural and biological resources: land formation, and the use of the land for forestry, infrastructure, animal husbandry, fisheries and agriculture (section 12.2). The second theme is the people and the institutions: allocation of land to households and changed livelihoods because of social, economic and institutional transformation (section 12.3). The last story line is climate change: what consequences it has for the people, and for formation and use of land in the central region of the coastal zone (section 12.4).

Each of the chapters ended with a number of concluding remarks, usually containing views on what will or should happen in the coming years. In the last section (section 12.5) of this chapter, and of the book, a number of these views are revisited and structured. This can be considered as an agenda for the future, as far as the contributors to the book are concerned.

14.2 FORMATION OF LAND AND SUBSEQUENT USE OF NEW LAND

The Meghna Estuary forms the central and most dynamic part of the coastal zone of Bangladesh. It is being shaped by a very complex set of interactions between physical processes. Factors that are particularly important in determining the outcome in terms of accretion and erosion are the sediment load, its transport and its distribution; the discharge of water and the water levels; and tidal forces and estuarine circulation. On average, around 1,100 million tons of sediment are carried down by the Ganges-Brahmaputra-Meghna rivers, the largest sediment load in any river system in the world. About one fifth of the sediment load is retained in the estuary, forming the raw material of the land accretion process. Surveys, based on satellite pictures, have shown that each year there is a net accretion of around

15-20 km^2. The accretion dominated around islands south and south-east of the Noakhali mainland, Jahazer Char and south-west of Bhola.

In practice it is the policy to transfer newly emerged chars to the Forestry Department for a period of 10 to 20 years for forestry development, in most cases in the form of mangrove plantations. The benefits of coastal afforestation are greater safety (protection against tidal bores and storms), improved ecological conditions (carbon sequestration, habitat for wildlife, protection of aquatic resources, decrease in salt intrusion, enhancement of soil fertility) and a better economic situation (production of wood and fruits). Over the last sixty years, the coastal area under forest increased with about 210,000 hectares. But substantial parts, maybe around 40%, were destroyed due to erosion and human encroachment. As far as additional forested area is concerned, a study has indicated that it would be possible to establish a coastal greenbelt of 127,000 acres (51,400 hectares). The social forestry approach (active participation of settlers in planning, planting and benefit-sharing), aiming at empowerment of local communities, augmentation of income and environmental protection, was on a wide scale introduced in the 1980s. An important part of this approach is the formation of Social Forestry Groups. There is a huge potential in the coastal zone, as well as in the whole country, to introduce the social forestry approach.

Once the period under the Forest Department is over, or once the area is heavily encroached before that time, a decision has to be taken whether to leave the area unprotected or to protect the area and construct a polder. The most important factor in taking this decision is the land level. It is generally understood that, in tide-dominated areas, land accretion slows down to almost zero when land levels reach about Mean High Water in the monsoon season. It is therefore a sensible guideline not to start polder construction before that level has been reached. A second factor of importance is the size of the polder to be. In this respect, the delineation of the water catchment area should be considered; it is in general recommended to include the whole catchment area in the polder. The economic feasibility of the polder depends on the balance between increased income (largely because of improved conditions for agriculture) on the one hand and costs of investment and operation and maintenance on the other hand. A large area vs. embankment length will be more economical. A first identification of the ecological characteristics (a third factor) of the area to be protected should be undertaken. Based on existing data and field surveys, an estimate has to be made of the impact of empoldering. A more extended Environmental Impact Assessment is necessary if investigations proceed to feasibility level. The construction of a polder may deteriorate the drainage of the adjacent land-side areas (a fourth factor). Proper drainage of adjacent agricultural lands should be an important design aspect of new polders. If it is not possible to avoid impeding the drainage of nearby areas, it would be preferable to leave the area under consideration unprotected. Worth mentioning is the fact that in 2017 the Bangladesh Water Development Board adjusted the design criteria for embankments and drainage systems in the light of the changed predictions of the impact of climate change.

The infrastructure in unprotected areas is geared towards basic needs of the settlers, such as providing drinking water and enhancing their safety. Deep tube wells, sanitary latrines, cyclone shelters and roads usually form the main elements of the package for those areas. For polders, much more infrastructure is required. Embankments, sluices and channels for drainage by gravity, are obviously the most essential structures. Protection of embankments, roads and other infrastructure by trees should always be a part of polder development. In both unprotected and protected areas, ponds are an important fresh-water source. Also, the capacity for retention of water in the system of *khal*s is important in this respect. Rainwater harvesting should be stimulated.

The status of infrastructure is directly related to safety and to economic development. Inferior quality of embankments threatens lives, while leaking sluices allow salinity intrusion and consequently impede agricultural production. Bad roads hamper communication. There is arguably more wear and tear of structures in the exposed coastal zone (salinity, storms, erosion) compared to other parts of the country. Operation and maintenance is therefore a major issue that has to be vigorously addressed. The level of allocations for O&M for water related infrastructure over the last decade is however not encouraging.

In the chars, a transition in aquatic livelihoods can be witnessed, that can be summarized as a movement from capture to culture and which is accelerated in case polders are constructed. The early settlers, migrating to freshly emerged land, are, as far as fisheries is concerned, fully occupied with marine fishing (hilsa, chewa, post larvae of shrimp, crab). Through the trapping of wild fish of both marine and freshwater species in open ponds, the char population moves gradually towards adoption of aquaculture. Households are also engaged in catching fish in the numerous *khal*s that cross he chars. In the process of change from capture to culture, a continuous spectrum can be seen, from a simple ditch towards a fully developed pond with raised dykes around it. Species and culture methods will be different for each part of the spectrum. Polders limit the opportunities for inland capture fisheries, because canals will be closed off from the sea. The potential for aquaculture is, however, increased in embanked areas, due to the fact that ponds are safe from flooding. Based on field experience, key factors for aquaculture in ponds are: appropriate pond preparation, selection of species that use the different ecological niches in the pond, judicious feeding, and multiple harvesting. The prospects for further development of aquaculture in the chars are bright. To realize the potential three key issues have to be addressed: appropriate technical interventions, strengthening of the institutional basis, for instance with regard to extension services, and secure land tenure.

In unprotected areas, where still only grass can grow, animal husbandry can flourish. It becomes a crucial part of the household economy, as a source of food and of financial and social security. Cattle and buffalo, and to a lesser extent sheep and goats, become what has been termed as a 'walking bank balance', with offspring as interest. But within a polder, space for tending cattle is restricted, because land is used for infrastructure, agriculture and aquaculture. In embanked chars, fewer households rear large and small ruminants. Households are involved in poultry in both unprotected and protected land; poultry gains in relative importance within polders. There is considerable room for improvement in the rearing systems in the chars. A main constraint is the isolation of char areas with the consequence that farmers have no, or limited, access to extension services and animal health care. Most households continue to rear native breeds of ruminants and poultry, mainly under extensive grazing or backyard scavenging systems, with limited supplementary feeding. Faced with widespread problems of animal health, most farmers do not apply a strategy of prevention and only treat their animals when they fall ill. Improved breeds and regular vaccination of stock would be steps in the right direction. If animal husbandry wants to continue to make a real contribution to livelihoods in coastal areas, a degree of intensification is required, not unlike the shift from capture fisheries to aquaculture. Services from the Government as well as from the private sector must be expanded and improved.

The cropping seasons in agriculture are largely determined by the rainfall pattern: *aus* from March to June, *aman* from July to November and *rabi* from December to March. In unprotected areas, *aman* rice of traditional varieties will often be the be the only rice crop. A limited range of *rabi* crops (mostly vegetables) will also be grown. The construction of a polder will lead to an expansion of the area that can be cultivated (especially in the *aus* and *rabi* season), while introduction of high yielding varieties is possible, due to the improved water management system. A dramatic increase in cropping intensity and in yields can be seen in many protected areas. Still a wide range of constraints can be observed. The very restricted availability of fresh surface water in the dry season and the embargo on use of groundwater for irrigation, makes large scale irrigation in char areas elusive. The embargo is based on the uncertainties of the effect of groundwater extraction on intrusion on saline sea water. The shortage of fresh water could be eased by increasing the depth of privately owned ponds and by constructing more large community ponds. Transporting water from a distant source to the south-central coastal zone might be investigated. Soil salinity is a second significant constraint. The trend of salinity levels in unprotected areas is not very distinct, with only areas located further from the coastline, showing a slow decrease. Within polders the general tendency is a lowering of salinity levels, with periods of increases in salinity making the trend quite erratic. Certain cultural techniques can help to reduce or cope with soil salinity. More importantly, an area should only be protected when the land level is sufficiently high to allow proper drainage. Research that is more targeted to the problems in coastal areas, for instance on suitable crop varieties for saline areas, and improved extension services, will help the agricultural sector to develop.

14.3 PEOPLE AND INSTITUTIONS

Families migrate to new lands for a variety of reasons, the main reason being that people have lost their original land and homesteads because of erosion. Many of them will move to newly emerged lands. At the early stage of migration, the char population is heterogeneous and lacks social cohesion. In their search for shelter and a new livelihood, they are often guided by a power broker, in many cases with ancestral links to newly accreted char land. These *jotdar*s and their *bahini*s (armed gangs) usually impose a regime of fear on the settlers. They extract relatively large amounts of money from them, in exchange for "protection" and for the control over and use of a piece of land. The immigrants and occupiers of land begin with felling trees, constructing thatched houses on raised mounds and digging ponds for drinking water and a little fish trapping. In winter, most ponds will fall dry however. There is hardly any system of communication. For food, the settlers are dependent on a low-yielding rice *aman* crop, some *rabi* crop and little fish grown in ponds or caught in open waters. Some income is derived from tending cattle, often on share-cropping basis. People have no official title on the land they occupy. They are facing a set of vulnerabilities as flooding, storms and salinity intrusion. No institutions are present, except for samaj (local communities), mosque– and madrassa committees, and a possible presence from the Forest Department.

Over time, the Government will gradually increase its influence in these remote areas. In most cases, this starts with establishing a police camp. Perhaps more importantly, a big step forward in the process of development of institutions are the field level organizations established by state agencies through a number of development projects. Good examples are the Water Management Organizations, Farmer Forums and Social Forestry Groups. Also, NGOs will move in and start their livelihood-oriented programs, starting with group formation. Through these development activities, state agencies employ their activities in the chars. Local government institutions are confronted with the problem that a large number of people and considerable land areas are added to their jurisdiction. Their staff and resources, meager at the best of times, are not adequate to cope with the changed circumstances. However, local government institutions are important in their own right and as a conduit between government organizations and the communities. The quality of the relations between local government, state agencies and community-based organizations has proven to be vital for further development. With some delay, private sector institutions as banks and suppliers will set up office in these areas. Markets are developed and gradually the char becomes more and more connected with the outside world.

A water-shed event in the livelihoods of the settlers is the official allocation of *khas* land, based on a government policy document of 1997. The policy states that land in newly emerged areas belongs to the state and has to be distributed to land less households, with a number of exceptions. This means a great step forward for the settlers and gives them control over a key natural resource. The struggle has now shifted to keeping control over their land, to having their fair share of water resources, and to equity in the sharing of benefits of public lands. The security of having a land title has instilled self-confidence and enhanced the settlers' status.

The higher institutional density (increase in presence of government, birth and growth of a series of community-based organizations and establishment of private sector institutions), the greater social cohesion among households, the progress in economic terms (fueled by infrastructure development) and the higher availability of social services, have, in concert, over the years led to a vastly different socio-economic scenario. It is safe to say that development efforts have resulted in more vibrant and stronger char communities. The social fragmentation has decreased, and vulnerabilities are less threatening than before. The formation of community-based groups has strengthened the position of the settlers, both men and women, in the struggle over control of natural resources. These grass-root groups have stimulated cohesion and fostered an atmosphere of cooperation, and of solving conflicts in a peaceful manner. The people have learned what their rights are and now know how to pursue them. Their physical security is enhanced by infrastructure like roads, cyclone shelters and embankments. They are economically much better off, largely through higher production in agriculture and aquaculture, and the opening up of the char through better communications. Char women have been enabled to diversify their activities and often significantly improve their livelihoods.

People have already experienced and recognized climate change related phenomena in their own environment. Perceived changes were, among others, uncommon rain fall patterns, higher temperatures, regular occurrence of drought and higher frequency of cyclones. Their perceptions are very similar to the results of scientific observations and analyses. As a response, coastal communities have started adapting and modifying their lifestyles to cope with these changes. Any outside support should be built on these indigenous, community-based adaptations and should recognize that people's resilience is at the heart of climate change adaptation.

14.4 CONSEQUENCES OF CLIMATE CHANGE

The trend in land formation and erosion in times of climate change is difficult to predict. The higher discharges from the river system in monsoon time will likely result in more sediment and more accretion, but it will impact adversely the rate of erosion as well. Monitoring of important variables will provide the required information and data necessary for a responsible analysis. They are the sediment load and distribution, the discharge of rivers, the subsidence and the most up-to-date projections of sea level rise. The combined effect of subsidence and sea level rise, based on current knowledge, is 10 to 12 mm a year. Sedimentation must at least be of the same magnitude for new land to emerge. The current average annual sedimentation rate is 20 to 30 mm. But given the uncertainties surrounding the impact of climate change, one should be cautious of drawing firm conclusions with regard to the future.

The elevated water levels of the ocean, the higher probability of storms and storm surges and the more erratic rainfall pattern (all associated with climatic change), lead to the inevitable conclusion that current design standards for water management related and other infrastructure have to be reconsidered. To address the combined effect of sea level rice and subsidence, the crest level of embankments have to be raised. The capacity of sluices should be increased because more rain will fall in shorter periods of time. As noted, BWDB adjusted the design criteria of water management infrastructure in 2017. Structures like houses, bridges and roads, and also boats, need more strength to cope with the stronger winds.

Mangrove plantations can be seen as a prime weapon against the impact of global warming. The ability of mangroves to cope with high levels and different types of stress and their innate resilience are very valuable in a changing environment. Particularly useful is the function of mangroves as protection of coastal areas against cyclones and storm surges. The intensity of tropical cyclones will likely increase, leading to enhanced storm surges and coastal flooding. Cyclones may penetrate further inland, causing the number of people that live in cyclone high risk areas to grow. Expansion of the area under mangroves is an obvious priority in times of climate change.

The marine fishery is already under pressure from the shift of fishing grounds related to siltation and overfishing. The higher incidence of stormy weather is likely to have a further adverse impact. Construction of stronger boats and training of fishermen are measures that will mitigate the situation somewhat. Local communities involved in inland fishing need to be assisted in analyzing their changing environment and in addressing the threats to livelihoods, caused by climatic events. As far as aquaculture is concerned, there may be a need to adjust the species mix in relation to the salinity. Flooding and water logging may require adjustments in pond design and a larger role for community-based systems.

Recent cyclones have shown the devastating effects cyclones can have on the livestock sector. It is expected that the frequency and intensity of cyclones will increase. The health of animals can be affected by higher temperatures because of heat stress. Outbreaks of livestock diseases will likely happen more often. Water shortages will certainly have an adverse influence, while also the availability and quality of fodder might suffer. Adaptive research and the use of it in Farmer Field School learning sessions, will equip local farmers with the knowledge and decision-making skills to adapt to a changing environment.

In agriculture, the supply of fresh water will probably become an even greater issue than it is at the moment. Practical measures that can be taken are the establishment of bigger and deeper ponds, to maximize the capacity to store fresh water just before the outside water turns saline at the start of the dry season. More information about groundwater aquifers is needed to assess if groundwater is to be safely extracted, without inducing salinity intrusion. The required adaptation of cropping patterns has to be based both on the views and experiences of local farmers, and on results of research efforts. Saline-resistant crops and on soil management measures that improve plant growth in saline conditions, are important research subjects.

It is no surprise that the consequences of climate change feature prominently in the Bangladesh Delta Plan 2100. This long-term plan takes the Adaptive Delta Management approach, which essentially means managing uncertainty, being ready to face immediate threats and adapt to changing situations or apply better solutions when they become available. The Plan is a unique example of ADM with its long-term orientation and short-term action. The Plan covers the whole of the delta area, with emphasis on six so-called Hotspots, the coastal one being one of them. It provides strategies for major climate change related issues (such as floods, drainage congestion, salinization).

The improvement of institutional implementation capacity and an Investment Plan are an integral part of BDP2100. It recommends delta-related interventions through new projects as well as maintenance of old and new projects.

14.5 AN AGENDA FOR THE FUTURE

14.5.1 Increase Understanding of and Monitor Estuarine Processes

It is essential that the current understanding of the processes taking place in the Meghna Estuary is enlarged and constantly updated. A permanent program of surveys and monitoring is required to achieve a solid information — and knowledge base. Such a base is a prerequisite to determine the consequences of climate change for the physical systems in the estuary, in particular for land formation, erosion and protection of coastal areas. Sediment transport and distribution, land accretion, erosion, tide and salinity are elements to be included in the proposed permanent program. Effective institutional arrangements should be put in place for the implementation of the survey– and monitoring program, for the processing and analysis of the collected data, and for the translation of these data into realistic policy recommendations.

14.5.2 Stimulate Land Accretion

There are multiple benefits of additions to the land mass of Bangladesh. It can mitigate the population pressure to a certain extent and more land will be available for food production. New land in front of the coast will increase the safety of the mainland and is a tool in the process of coping with the impact of climate change. Implementation of the planned program of land accretion schemes should be taken up as priority, while surveys to identify new potential land accretion areas have to be carried out. The BDP2100 recognizes the enormous potential of land reclamation in the estuary and recommends a three pronged strategy: research on morphological behavior, construction of cross dams to accelerate land accretion and land use plans for the reclaimed land.

14.5.3 Implement Integrated Coastal Development Programs

People living in the coastal zone are faced with severe threats as cyclones and storm surges, drainage congestion and water logging, droughts and salinity intrusion, erosion and deteriorating ecosystems. Moreover, most of the households, in particular in the exposed low-lying char areas, have to cope with backward socio-economic development. The set of vulnerabilities that people have to face are of such diverse nature, and so severe in character, that they cannot be addressed by a single intervention. It requires a multi-sectoral approach, which necessarily means the involvement of multiple agencies. The experiences with the Char Development and Settlement Project, implemented in the southern part of the greater Noakhali area since 1994, are such that the CDSP-model can be regarded as the best practice for design and implementation of integrated programs. Three concepts are central to the approach: 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). Feasibility studies must be undertaken, preferably in the framework of a regional development plan, for new areas where integrated development programs can be initiated. For the identification of unprotected accreted areas that can be embanked and turned into a polder, the rule of Mean High Water in monsoon time should be applied: when an area remains dry during MHW in the monsoon season, it qualifies for protection.

14.5.4 Allocate Funds for Implementation of Mangrove Plantations

There are convincing arguments for investments in the further development and extension of mangrove forests. Mangroves have multiple functions with a favorable impact on the estuary: the protect soils from erosion, add organic matter to the soil, stimulate mud flat formation, dampen the effect of wind– and wave action, accelerate the process of stabilization of newly formed chars and serve as water filter for ecosystems and provide a natural spawning ground for fish and crustaceans, especially for shrimps and prawns. The Center for Environmental and Geographic Information Services (CEGIS) undertook a study on a potential greenbelt zone in the coastal regions of the country. The study proposes a contiguous greenbelt extending from the eastern boundary of the Sundarbans to the southwest tip of Teknaf. The width of the greenbelt would vary from 200 m to 1000 m, depending on the specific local circumstances, such as height of storm surges, vulnerability, presence or absence of embankment and critical infrastructure and existing forest cover. The study report delineates a proposed greenbelt of in total nearly 127,000 hectares. As part of the investment plan, a priority index was included in the study, with top priorities for Upazilas in the central region of the coastal zone, the subject of this book. The Government should undertake efforts to create a fund for coastal afforestation, with contributions through public/private partnerships and from international financial institutions.

14.5.5 Develop a Land Management System for the Period Between Accretion and Settlement of People

The illegal encroachment by settlers of relatively recently formed, mangrove covered chars that are still under control of the Forest Department causes considerable harm to the environment. The encroachment is in most cases accompanied by unlawful practices of locally powerful people and their henchmen. A creative solution has to be found to balance the need of forestation for water– and soil conservation on the one hand, and the need to settle people on the other hand. The people involved can be seen as environmental refugees, since most of the illegal settlers have lost their land elsewhere due to erosion. An improved land management system for the period between the emergence of the new land and the moment it is finally handed over to the civil administration for settlement, must be designed and implemented. A key feature of such a system will be the application of the social forestry approach to the plantation and maintenance of mangrove forests.

14.5.6 Develop a Mechanism to Solve Boundary Issues

The dynamic nature of the central part of the coastal zone, with active processes of accretion and erosion, compounds the problem of determination of the jurisdiction over the new land. The Government has not enough technical manpower to continuously update the status of the newly formed chars. In the past, many areas have changed again, before the official surveys were published. The uncertainty about the exact administrative status (as questions to what District or Upazila the char belongs) easily leads to conflicts over boundaries and delays development works. A proper mechanism with a fixed procedure to address such disputes could prevent many of these uncertainties.

14.5.7 Regularly Review Design Criteria

To address climate change related phenomena (higher sea levels, more and stronger storms and storm surges, erratic rainfall), design standards for a broad range of infrastructure, with special attention for water management related structures have to be regularly reviewed and adapted. The height of embankments, the capacity of drainage sluices and the strength of structures, should be made suitable for the changed environment. Design– and construction guidelines for coastal infrastructure should be updated in view of available knowledge and technology. The adjustment in 2017 of the BWDB design criteria for embankments and drainage systems are a good example of taking into account new insights in the consequences of climate change.

14.5.8 Attach High Priority to Operation and Maintenance (O&M)

Wear and tear of infrastructure in exposed coastal areas is arguably more severe than in most other areas. Both safety and economic production are served by adequate maintenance. Allocations and actual expenditures for O&M for the main infrastructural agencies therefore have to be dramatically increased, while households and local government have to bear a share of the burden. Cooperation between government agencies, communities (especially Water Management Organizations) and local government must be vigorously promoted. Multi-year maintenance agreements between those parties will come a long way in fostering and structuring this cooperation.

14.5.9 Continue and Intensify Formation of Field Level Institutions

Field level, community-based organizations, play a crucial role in the social and institutional transformation in the newly inhabited chars. The same can be said of their role in the process of coping with the effects of climate change at community level. They are key parties when it comes to the questions of operation and maintenance of infrastructure as well. In future programs, local organizations such as Water Management Organizations, Farmer Forums, Social Forestry Groups and NGO-groups, have to be established. Area-wise platforms where all the community-based groups can meet and exchange views and experiences would be a welcome addition. These institutions are in a unique position to form the initial linkages with the upper tiers of the administration and play a key role in the community-based adaptation to the consequences of climate change. The links between field level institutions and the private sector is an issue deserving attention. As is emphasized in the BDP2100, the Participatory Water Management Rules should be rigorously implemented at local, regional level and national level.

14.5.10 Support a Process of Strengthening Local Government

Like the community-based groups, local government institutions, at Upazila– and Union level, are indispensable in the development and governance of remote coastal areas. For every measure, aimed at adapting to the impact of climate change at grass-root level, involvement of local government will be necessary. Participation as well as strengthening local government should form a part of every development effort. The Government should further implement the declared policy of decentralization in order to give the local government the resources and the institutional room to execute its functions. Local government institutions are essential in times of disaster, in the coastal zone in particular in the case of cyclones. Upazila- and Union Parishad representatives need to be provided with basic knowledge on the impact of climate change, so that they are able to take informed decisions in their area.

14.5.11 Develop and Disseminate Knowledge

Solid research and technology generation are a way forward to further development in the estuary and to the process of coping with the consequences of climate change. Subjects could be, among many, the consequences of extracting groundwater for salinity intrusion, screening of crops and crop varieties against soil salinity, appropriate technologies to make the most of the potential of aquaculture in coastal polders and the mitigation of diseases among animals. The research should be, as much as the subject allows, adaptive research, designed and implemented with local communities. It is crucial, not only to undertake research, but to make the results known to a large public, ranging from the research community itself to policy makers, implementers and families in the coastal areas. Organizations should embark on a system of courses and refresher courses for their own staff to disseminate newly developed knowledge. Policies ad the design of programs should become more knowledge based.

14.5.12 Work on a Long Term Regional Plan for the Central Coastal Zone

Erosion and accretion in the estuary are permanent phenomena, the result of a complicated physical process, with significant social consequences. Climate change will have an impact on both the physical system and on the social dimension. Devising policy measures to address the development in the estuary, would greatly be helped if these measures could be based on a long term regional plan. The idea of regional plans has been promoted by the National Water Management Plan and the Water Act 2013. The Plan identifies the Meghna Estuary as one of the planning units. The Bangladesh Delta Plan 2100 argues for regional tailoring of national plans; in particular regional strategies for the coastal zone water management and spatial development have to be prioritized. A regional plan for the central part of the coastal zone could form a part of such an overall plan for the whole coastal zone. It could result in a broad range of measures, from identifying feasibility studies for land accretion, char development and rehabilitation of polders, from spatial planning to economic development, and from engineering works to awareness raising campaigns, research on topics pertaining to the estuary and knowledge dissemination.

14.5.13 Start Mainstreaming and Implementing the Bangladesh Delta Plan 2100

BDP2100 recognizes the significance of the coastal zone by identifying the zone as one of the six Hotspots and by giving ample attention throughout the Plan to coastal issues. They include both challenges and potential for future development, such as the "blue economy". The Plan develops strategies and sub-strategies, followed by prioritized projects and programs. Relevant for coastal areas are, among others, development and improvement of embankments, drainage improvement, restoration of waterbodies, improvement of O&M, flood and storm surge proofing of buildings and houses, expansion of the number of cyclone shelters and enhancement of early-warning systems. For the central part of the coastal zone, the focus of this book, the interventions to accelerate land accretion, the rehabilitation of water management infrastructure (for instance on Bhola island), the continuation of the Char Development and Settlement Project in a new phase and research on the morphological behavior in the Meghna Estuary are of particular interest in the short to medium term. It is important that the proposed prioritized projects and programs are mainstreamed in the sense that they will be taken up in the cycle of annual- and Five Year Plans, starting with the 8th Five Year Plan and subsequent Annual Development Programs.

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