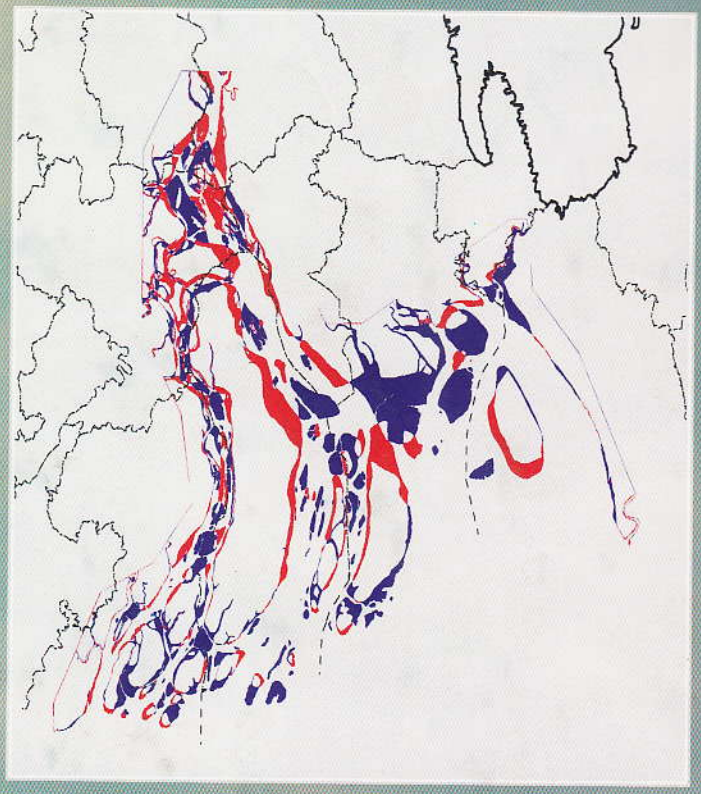
Moving Coastlines



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

edited by Koen de Wilde

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. Currently, he is Chief Technical Adviser of CDSP III, on a contract with Euroconsult Mott MacDonald.

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List of Abbreviations and Acronyms

ADB	Asian Development Bank
ADP	Annual Development Plan
AEZ	Agro-Ecological Zone
ASPS	Agricultural Sector Programme Support
BCCSAP	Bangladesh Climate Change Strategy and Action Plan
BRAC	Bangladesh Rural Advancement Committee
BT	(Char) Bhatir Tek
BUET	Bangladesh University of Engineering and Technology
BWDB	Bangladesh Water Development Board
CAARP	Community Agriculture and Aquaculture Resource Person
CAP	Climate Change Assistance Programme
CBA	Community Based Adaptation
CBO	Community Based Organisation
CDS	Coastal Development Strategy
CDSP	Char Development and Settlement Project
CL	Char Lakhi
CO2	Carbon dioxide
DC	Deputy Commissioner
DAE	Department of Agriculture Extension
DPHE	Department of Public Health Engineering
dS	Deci-Siemens
ECe	Electrical conductivity equivalent
EDP	Estuary Development Programme
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Study
ESCAP	Economic and Social Commission for Asia and Pacific
FD	Forest Department
FF	Farmer Forum
FFS	Farmer Field School
GDP	Gross Domestic Product

GNAEP	Greater Noakhali Aquaculture Extension Project
GT	Gangchil-Torabali
ha	Hectare
HYV	High Yielding Variety
ICZM	Integrated Coastal Zone Management
IMED	Implementation Monitoring and Evaluation Division
IPCC	Intergovernmental Panel on Climate Change
IPSWAM	Integrated Planning for Sustainable Water Management
IUCN	International Union for Conservation of Nature
JCS	Joint Cooperation Strategy
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	(Char) Mora Dona
me	Milli equivalent
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
NGO	Non-Government Organisation
NSC	National Steering Committee
NWRC	National Water Resources Council
O&M	Operation and Maintenance
°C	Degree Celsius
PBSA	Participatory Benefit Sharing Agreement
PLDP	Participatory Livestock Development Project
PDZ	Productivity Zone
p^H	Anti-Logarithm of Hydrogen ion concentration
PL	Post larvae
ppm	Parts per million
ppt	Parts per thousand

PRSP	Poverty Reduction Strategy Paper
PVA	Participatory Vulnerability Assessment
PWD	Public Works Datum
RFLDC	Regional Fisheries and Livestock Development Component
RRMAC	Rural Roads and Market Access Component
SFG	Social Forestry Group
SFYP	Second Five Year Plan
SH	South Hatiya
SLDP	Smallholder Livestock Development Project
Tk	Taka (Bangladesh currency)
TUG	Tube Well Users Group
UNDP	United Nations Development Programme
UP	Union Parishad
WARPO	Water Resources Planning Organisation
WMA	Water Management Association
WMC	Water Management Committee
WMF	Water Management Federation
WMG	Water Management Group
WMO	Water Management Organization

Glossary

Agrahayan	Eighth month of Bangla calendar
Aman	Monsoon season rice
Arhar	A pulse herb
Arjun	Timber tree
Arot	Depot
Aus	Summer season rice
Bagda	Black tiger prawn cultivated in brackish water
Bahini	Armed gang
Bajal	Local rice variety
Ban	Forest
Batham	Large herd of cattle reared in open grazing land
Bigha	One third of an acre of land
Borga	Mortgage
Boro	Winter season rice
Burkha	The veil used by Muslim women to maintain purdha
Charcha	A draft survey map prepared for immediate settlement by collector
Chewa	Indigenous fish species
Chingri Mohal	Land earmarked for shrimp culture
Dadander	Person doing business on advance payment
Desia	Local
Dhora	A type of survey of coastal and urban land
Durga Puja	Biggest Hindu religious festival
Eid	Biggest Muslim religious festival
Eid-ul-Azha	Muslim festival marked by sacrificing animal
Falgun	Eleventh month of Bangla Calendar
Ghats	Place where boats embark
Gher	Large area of fish cultivation
Golda	Giant fresh water prawn
Gorur Hat	Cattle market
Gulla	Small catfish

Haat	Weekly market
Hali	(group of) four
Jamabandi	Document containing full description of the land to be settled to a family
Jarul	Timber tree
Jhau	Tree species
Jotdar	Powerful person having big agricultural farm
Khabuliyat	Deed of agreement
Khal	Cannel, creek
kharif-I	Crop season covering March/April to June/July
kharif-II	Crop season covering July-December
Khas	Government owned land, DC disposition authority
Khudra Dol	Small group
Killa	Raised mud bed used as shelter for cattle
Macha	A false ceiling in the house used as for storage
Madrasa	Traditional religious schools for Muslim children
Mouza	Basic unit used in revenue map
Pangas	Catfish species
Paribesh	Environment
Paravet	Person trained for treatment of livestock
Purdah	Literally, a curtain or veil; Muslim practice of female seclusion and isolation from men outside their immediate family
Rabi	Crop season; November/December to March
Ranikhet	Newcastle disease of chicken
Ricksha	A tri-cycle driven by man
Sadar	Upazila that includes district headquarter
Samaj	Formed by a small number of families that live in close association, identify themselves as separate social unit
Samannyan	Coordination
Shalis	An indigenous judicial meetings
Thana	Police station
Tin	Corrugated Iron sheet used for making house, fencing etc.
Tota	Traditional tool used for fishing
Unnayan	Development
Upazila	Sub-district

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Foreword

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.

Dhaka, December 2010

Alphons Hennekens
Ambassador of the Kingdom
of the Netherlands in Bangladesh

Preface

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 previous 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 organisations 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

Sultan Ahmed, Koen de Wilde

1.1 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 of 2006 (see Section 1.3), 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 (5 dS/m) and groundwater (2 dS/m) salinity levels. All areas with higher values were seen as coastal. A cyclone risk map (prepared by the Disaster Management Bureau) 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 (seven 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 484 Upazilas. In the Coastal Development Strategy, an Upazila is considered to be coastal as one or two of the aforementioned parameters is above the threshold that was set. Subsequently, a District is taken as coastal when it includes one coastal Upazila. Along these lines, 133 Upazilas can be identified as being coastal. These 133 Upazilas are located in 19 Districts. In 48 Upazilas, situated in 11 districts, all three indicators are above threshold level. They are referred to as the exposed coastal zone. The 19 Districts of the coastal zone have a combined area of 47,200 square kilometres, 32% of the total area of Bangladesh.

Coastal resources are under pressure worldwide. It is estimated that about 40% of the world's population lives within a band of 100 km of 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.

Bangladesh shows the same tendency. Although the 19 Districts in the coastal zone occupy 32% of the country's surface and have 28% of the population, coastal areas are becoming more heavily populated due to migration and population growth. Even in sea facing coastal chars, a density of 1,000 people per square kilometre is not uncommon.

1.1.2 Regional Differentiation

As is done in the Government's Concept Note on Integrated Coastal Zone Management of 1999 (see Section 1.4), the 710 kilometres long coast can be divided into three distinct regions: east, central and western. 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.

Morphologically, the eastern coast of Bangladesh from Big Feni River to Badar Mokam (the southern tip of the mainland) along Chittagong 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 kilometres long sea beach. The

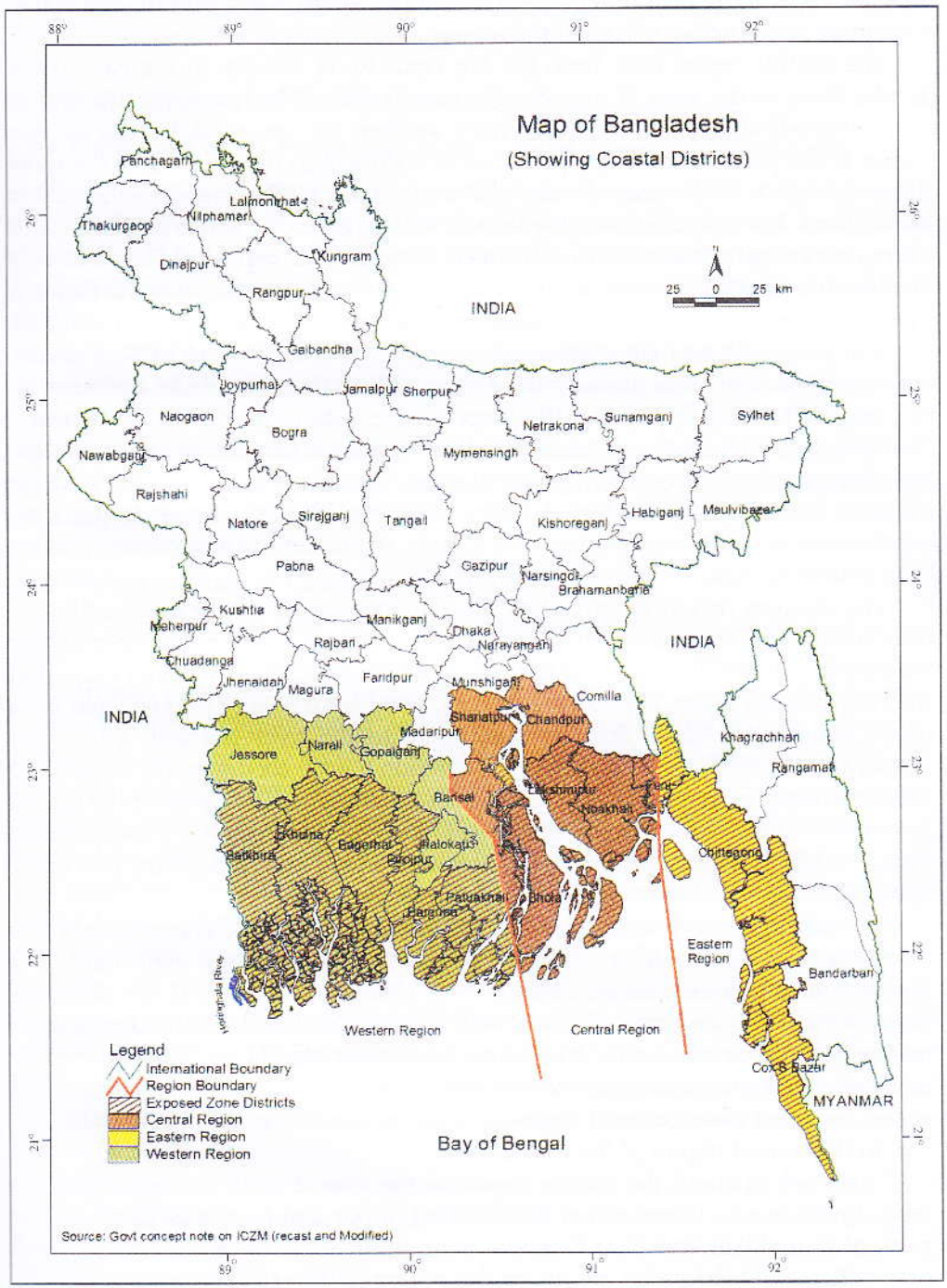

Figure 1.1: The coastal zone of Bangladesh and the three geo-morphological and hydrological regions

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 Fenri 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 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, Shahbazpur (Bhola), have appeared heading 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 large 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 earned by the rivers of the 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.

The whole of the coastal zone has 185 islands and chars. These islands and chars are classified as detached chars, chars attached with the main land, and marine and estuarine islands. Among these chars and islands, 21 are detached riverine chars, 92 are chars attached with the mainland and 72 are identified as marine and estuarine islands. Marine and estuarine islands are located within a tidal range of 2 to 6 meters (macro and meso-tide). They are located mostly in the eleven exposed-to-sea coastal districts. Most of the chars and islands also fall within the central region of the coastal zone.

This book is about the central region of the coastal zone, as mentioned the most dynamic one. It consists of Bhola, Lakshmipur and Noakhali Districts and parts of Patuakhali and Feni Districts. Shariatpur and Chandpur Districts and part of Barisal District also fall under this region, although they are not directly exposed to the sea. Much of the book focuses on the Greater Noakhali area, composed of the Districts of Laskhmipur, 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.

1.2 COASTAL COMMUNITIES AND RISKS

1.2.1 Urban and Rural Population in the Coastal Zone and Active Delta

In the 19 coastal Districts of the coastal zone live about 40 million people (projected population of 2010 based on the BBS census 2001). Around 26.5 million of them live in the 11 exposed Districts. The active delta (central region) comprises the Districts of Bhola, Lakshmipur and Noakhali and parts of Patuakhali and Feni districts where about 7.6 million people are living.

About 30.2 million people are living in rural—and roughly 10 million in urban areas of the 19 coastal Districts. In the active delta these figures are respectively 6.5 million and 1.1 million. Around 3 million people are living on the 185 chars and islands which is about 13% of the total population of the 11 exposed coastal Districts. People live seasonally in the 35 islands of the 72 marine and estuarine islands.

1.2.2 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 class of hazards is anticipated to increase in the coming decades with climate change. In particular the exposed part of the coastal zone, 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 labourer 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 and in particular 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.

1.3 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 Poverty Reduction Strategy and the Bangladesh Climate Change Strategy and Action Plan. The Perspective Plan of Bangladesh 2011-2021 is briefly highlighted as well.

1.3.1 Coastal Zone Policy and Coastal Development Strategy

The Coastal Zone Policy (approved by the cabinet in 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 (adopted by an Inter-Ministerial committee in 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
- Optimising the use of coastal land
- Promoting economic growth emphasising 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 document provide the institutional framework, with key roles for coordinating mechanisms at the national level (see next paragraph).

1.3.2 The National Water Management Policy and Plan

The National Water Policy 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 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 programmes for development of water resources.

1.3.3 Poverty Reduction Strategy Paper

The recently (December 2009) revised and adopted second Poverty Reduction Strategy Paper ("Steps Towards Change: National Strategy for Accelerated Poverty Reduction–II") covers the period 2009-2011. It recognises that climate change and climate variability have already been creating an adverse impact on the life and livelihoods of the population, particularly of those people who are living in the coastal areas. The revised PRSP-II emphasises mainstreaming and strengthening of climate change adaptation across various sectors. The Paper promotes, amongst others, afforestation, construction of cyclone shelters and embankments, and improvement of salinity control measures. It recognises water resources development and—management as critical areas for pro-poor economic growth. It gives directives to attach great importance to alleviate the sufferings of people in the coastal zone, stemming from diverse forms of deprivation. This has to be achieved both by disaster management and by improvements in water management.

The Paper recognises that the regional variation in poverty is noticeable. This regional variation is influenced by the incidence of natural hazards and tends to be higher in disaster-prone areas. The PRSP promotes a targeted approach, focusing on poor regions and within those regions on the most disadvantaged groups in the population. It particularly refers to areas vulnerable to adverse ecological processes such as "cyclone-prone coastal regions, chars, drought-prone areas and river erosion affected areas."

1.3.4 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. 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 programmes 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.

1.3.5 Perspective Plan of Bangladesh 2010-2021

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. 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, inequity and deprivation.

1.3.6 Harmonisation

There is without a doubt a highly supportive policy environment for an integrated coastal development programme that seeks to reduce poverty and increase the capability 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 as shown above. 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 harmonisation of the way the strategies are made operational. This lies at the heart of the approach propagated by the Integrated Coastal Zone Management concept. The next

paragraph will elaborate on this concept and on the present status of ICZM in Bangladesh.

1.3.7 Strategies to Address Climate Change

At the conceptual level, climate change and coastal development can not be seen as two separate entities. They are closely interlinked. The case for development of the coastal zone becomes all the more compelling because of anticipated changes in climate. At strategic and implementation level, both the CDS and the Bangladesh Climate Change Strategy and Action Plan should be implemented as a matter of the highest priority.

Acknowledging that not one single institution can achieve the momentous objective of protecting and improving coastal livelihoods, coastal development must be implemented in an atmosphere of partnership. Organisations from different sectors and with a variety of signature will have to collaborate in order to achieve the goals of the CDS and BCCSAP. Coordination is a prerequisite for the implementation of both strategies.

1.4 INTEGRATED COASTAL ZONE MANAGEMENT

1.4.1 The Concept of ICZM

In the development of coastal development, a shift in focus can be distinguished, looking back on the past fifty years. Till the 1970s, an emphasis was put on the sectoral approach, with low public participation. In the 1970s and 1980s the accent moves 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 with a system of public administration that is usually organised along sectoral lines. Governments faced the problem how to draw together diverging policies, strategies and implementation mechanisms in coastal areas. They gradually came to realise that an integrated or at least coordinated approach was absolutely necessary in the management of coastal resources.

The concept of Integrated Coastal Zone Management (ICZM) 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 polices and practices. Interesting examples in Asia are Sri Lanka, Indonesia, Vietnam and The Philippines.

1.4.2 History and status of ICZM in Bangladesh

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.

The first initiative on Integrated Costal 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 (ICZM) 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 programme.

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 17th January 2005), the Coastal Development Strategy (adopted by the Inter-Ministerial Steering Committee on 13th February 2006) and the Priority Investment Programme (drafted in 2005 and accepted in 2006). As was described earlier, the Coastal Zone Policy and the Coastal Development Strategy define to a large extent the context for the proposed coastal development programme.

However, after that project elapsed in 2006, core bodies as the Inter-Ministerial Steering Committee on ICZM and the Inter-Ministerial Technical Committee ceased to convene. The National Water Resources Council (NWRC), seen as a key coordinating and decision making body on ICZM had no meetings since April 2004. The planned Programme Coordination unit in the Water Resources Planning Organisation (WARPO) has no permanent staff members and is barely functional in respect of ICZM matters.

Clearly the institutional dimension of the ICZM process did not progress as much as the development of policies and strategies. To revitalise the process, the Bangladesh and Dutch Governments fielded a mission in January 2009 that resulted in a series of pragmatic recommendations. It was argued that the two main coordination mechanisms (the Inter Ministerial Technical Committee and the Steering Committee) should be convened again, while the urgency of coastal

development, should have a translation in the organisation of pivotal stakeholders in coastal development.

According to the Coastal Zone Policy, the Inter-Ministerial Steering Committee was to be set up "to provide policy guidelines on issues related to the coastal zone." The task of the Technical Committee is summarised in the Coastal Zone Policy as "removing planning and implementation bottlenecks and resolving inter-organisational conflicts." This high level committee is to be chaired by the Minister for Water Resources with Secretaries of the Ministries concerned as members.

A great need is felt for such a broad based entity that concentrates on discussing on and preparing solutions for issues of a wider nature than projects and matters of implementation. In a sense, the Technical Committee should be the real guardian of the Coastal Zone Development Strategy and should be responsible for revising the strategy whenever necessary. Topics to be raised in the Technical Committee meetings can range from ship breaking along the coast to the policy with regard to the use of newly accreted lands, and from oil pollution in the Bay of Bengal to the changed requirements for coastal protection and disaster management in the light of expected climate change and sea level rise. The preparation of a Coastal Zone Act, if deemed desirable, and the enforcement of existing legislation are other major subjects that need to be a part of the Technical Committee's agenda. And last, but not least, the ICZM Technical Committee should stimulate the preparation of new projects in order to bring the portfolio in line with the actual needs.

Another subject that needs to be high on the Committees priority list is the institutional translation of the urgency of coastal development. One could for instance think of a coastal wing in the Ministry of Water Recourses, generally accepted to be the designated Ministry for the coastal zone, and a coastal Directorate in the Bangladesh Water Development Board, the main implementing agency of that ministry. These organisational changes would not lead to higher personnel budgets, since they can be adopted within the available strength. Already a system of focal points exists, giving the ICZM efforts an entry point in each relevant Ministry and agency. These focal points are coordinated and supported by the Coastal Coordination Unit in WARPO.

The institutional translation has been given a political dimension: Members of Parliament of coastal constituencies have formed a platform that functions as a pressure group in the political arena and beyond. This platform can generate and consolidate support and commitment to development of the coastal zone. At the same time they can hold the Government accountable for indeed recognising the compelling case for coastal development and for undertaking the required measures to apply the Coastal Development Strategy and the Bangladesh Climate Change Strategy and Action Plan.

1.5 FUNDING FOR COASTAL DEVELOPMENT

The section on financing the Coastal Development Strategy identifies five sources of financing for development in the coastal zone: public sector investments; assistance from multilateral institutions and donors; NGO contributions; and private sector investments.

1.5.1 Public Sector Investment

Public investment in development is allocated sector- and Department wise, for specific projects and programmes. There is no specific 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 Programme (ADP). Funds are allocated project-wise in the ADP on an annual basis. Given this structure of allocation of public funds, it is difficult to find out exactly how much funds are allocated to the coastal zone. However, 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 last five years (Financial Year 2005/6-2009/10). 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.

The prospect of an increase in public sector investments on coastal activities is encouraging. Both the PRSP-II and the Sixth Five Year Plan (2010-2015) promote the integrated development of the coastal zone. Large projects already in the pipeline are, for instance, the bridge over the river Padma and the Ganges barrage. Both have the potential to contribute significantly to the social and economic development of the south western part of the coastal zone.

The Government of Bangladesh has established a Climate Change Trust Fund and has issued the *modus operandi* of the Fund's utilisation. US$ 100 million has been allocated from the Government's own resources for the period of July 2009-June 2010. The fund is being utilised to achieve the pillars and action plans of the BCCSAP 2009. The Ministry of Environment and Forest invited Ministries, Departments, universities, NGOs and civil society organisations to formulate proposals for activities that could be financed by the Fund. About 4,000 were submitted. The Ministry approved a number of the proposals, mostly from the Departments and universities, and allocated US$ 62 million from the Fund for these approved proposals. The same amount as for the 2009-2010 period (US$ 100 million) has been provided for the Trust Fund for the period of July 2010 to June 2011.

1.5.2 International Support

A part of the public sector funds have been and will be made available through development partners. There are enough indications from multilateral institutions and bilateral donor 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. It does not seem likely that donors would agree to channel funds for coastal programmes through one central fund for coastal development. A number of reasons can be cited: the uncertainty of the size and nature of the portfolio of projects that will be presented; the complex and diverse nature of ICZM activities; the fact that experiences with other examples of central pooling of funds for (sectoral) programmes 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; for some donors pooling of funds is not a priority under the policies applied to their country programme in Bangladesh. Government officials and donors alike are 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 donors form coalitions around projects or clusters of projects that reflect their policies and priorities in the best manner.

There is, however, a multi-donor commitment of US$ 110.00 million fund for Bangladesh as climate resilience Green Trust Fund. The Ministry of Environment and Forest, on behalf of the Government of Bangladesh, will administer the fund. From this trust fund, interventions in the coastal zone can be financed.

Donor agencies have regularly expressed their concerns about the implementation capability in the country. Low disbursements rates are an issue that worries many. Especially the water sector is under criticism. The long time of preparation of water resources projects and the slow execution are a cause for reluctance to invest in that sector. Also the macro planning in the water sector is questioned. Likewise, concerns about the strength of local government institutions are frequently raised. The general view is that the local government is the key level for implementation of ICZM activities. Capacity building at Union and Upazila level should have the highest priority. The pace of decentralisation is felt as too slow and needs acceleration.

There are also concerns related to the donor community itself. Principles laid down in the Paris Declaration on Aid Effectiveness were accepted and the process to come to a Joint Cooperation Strategy (JCS) is ongoing. But some distance has still to be travelled to realise to the full extent the commitments made with regard to harmonisation and alignment of aid delivery. The ICZM efforts are in general seen as being in line with the direction in which the donor community (or at least a sizeable part of it) is moving in terms of coordination and alignment, as long as it stays practical and result-oriented. Hesitations are expressed regarding the

feasibility of applying a (sub)sector wide approach in current circumstances. This approach had mixed successes in sectors as health and education. The multi-sectoral character of an ICZM programme would make it more difficult to successfully use the sector-wide approach. A number of donors are clearly considering to adopt a more area focused approach instead.

1.5.3 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 of the Government amounted to approximately US$ 290 million a year. The NGO funding in the coastal zone in the comings years is expected to increase as the SFYP and the Vision 2021 will be implemented with participation of the NGOs and the civil society organisations..

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. Overall, the Government makes only 16-17% of the total investment of the country. 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 greater 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.

1.6 DEVELOPMENT EFFORTS IN THE ACTIVE DELTA

As reflected in the previous paragraph, around US$ 1.45 billion was spent on coastal zone activities over the last five years from public sector funds. It would go too far to give a complete and exhaustive list of all the development projects and programmes 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, dynamic part of the coast: the different phases of the Char Development and Settlement Project (CDSP), the Estuary Development Programme (EDP), the Regional Fisheries and Livestock Development Component (RFLDC) and the project "Promotion of Adaptation to Climate Change and Climate Variability in Bangladesh."

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

1.6.2 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 three more implementing organisations joined: the Department of Public Health Engineering (DPHE) and the Department of Agricultural Extension (DAE). In that phase the project worked also in unprotected areas. 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, BRAC is coordinating the work of five local NGOs, working in the same area as the government component of CDSP. The project is known for its integrated set of activities, planned and implemented in a coordinated and participative manner. A fourth phase is being prepared for five chars in Noakhali and Chittagong Districts, with an implementation period from 2011 to 2017.

1.6.3 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, 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 project covered 15

Upazilas in the three districts of Feni, Lakshmipur and Noakhali itself. Several of these Upazilas correspond to the charlands. The Smallholder Livestock Development Project in the Five Southern Districts (SLDP-2) began in 2000 and was operational in the three districts of Greater Noakhali (Feni, Lakshmipur and Noakhali), 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 Componen (RFLDC), Noakhali, currently operating in Greater Noakhali, including the char areas. The main objective of this project is income generation for famers 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 Programme Support, Phase–II (ASPS–II).

1.6.4 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. 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 Programme.

1.7 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;

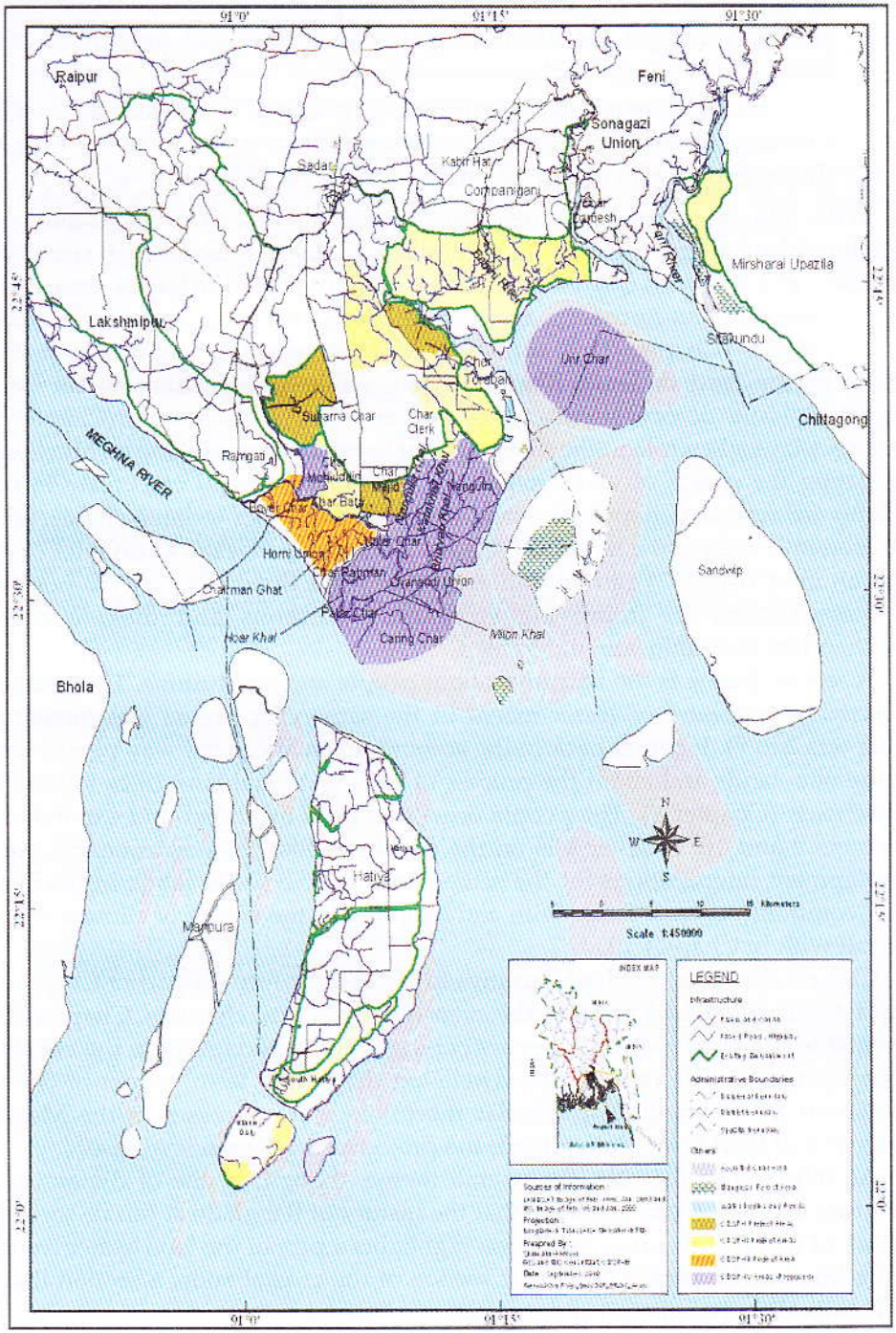

Figure 1.2: Areas of CDSP, RFLDC and Promotion of Adoption to Climate Change and Climate Variability Project

- the Government has created a positive policy environment for coastal development and the dawn of an ICZM institutional framework is on hand;
- donors 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 following chapters, 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—stabilisation, but 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 2 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 forms a part of Chapters 2, 3 and 4 and is touched upon in the subsequent sectoral chapters. Chapter 10 is devoted to the ways communities are coping with and adapting to the effects of global warming. The last chapter dwells on the longer term impact of climate change on the physical, in particular morphological, processes in the Meghna Estuary: will land formation outpace the projected rate of sea level rise?

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

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2.1 INTRODUCTION

This chapter intends to explain the rather complex processes that lead to accretion of new land and to the loss of existing land, and the possible interventions aimed at accelerating the accretion. 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 (Section 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 (Section 2.6) and with concluding remarks (Section 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 recognised, 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 and Urir 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.

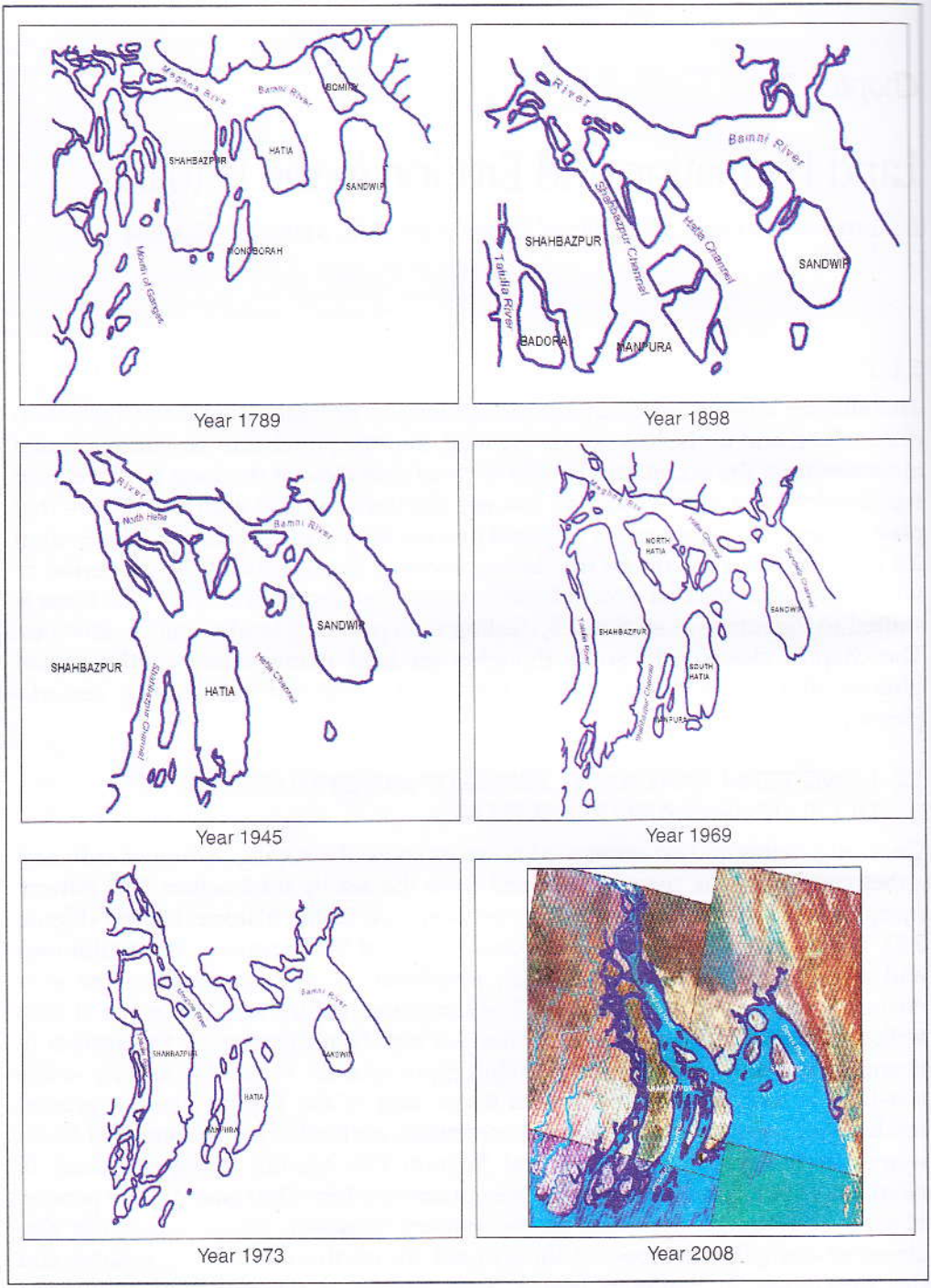

Figure 2.1: Historical trend of morphological development in the estuary

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 Hatiya 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.

2.3 FACTORS INFLUENCING THE ACCRETION AND EROSION PROCESS

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 Section 2.3.1). Investigations have shown that upland flow, tidal forces and estuarine circulation are important factors as well (Sections 2.3.2 and 2.3.3).

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 may have an impact.

2.3.1 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 tons to 1,400 tons. 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. Studies have shown, the sediment discharge is strongly related to the river discharge (see next section) 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. 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 2.3.3).

2.3.2 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. No significant trend is seen in the maximum water level at the three locations. The minimum water level of Ganges River shows a decreasing trend at Hardinge bridge. The same trend can be observed at Baruria in the Padma river. The minimum discharge in the Ganges at Hardinge Bridge and in the Padma River at Baruria shows a distinct decreasing trend. The minimum discharge in the Brahmaputra river (Jamuna) at Bahadurabad does not show any trend. The annual maximum discharge in the Ganges, the Brahmaputra and subsequently Padma rivers shows, however, an increasing trend. These diverging trends in annual characteristics of discharge and water level indicate enormous river dynamics that influence the coastal area and estuary.

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 characterised by extremely high water levels and river discharges.

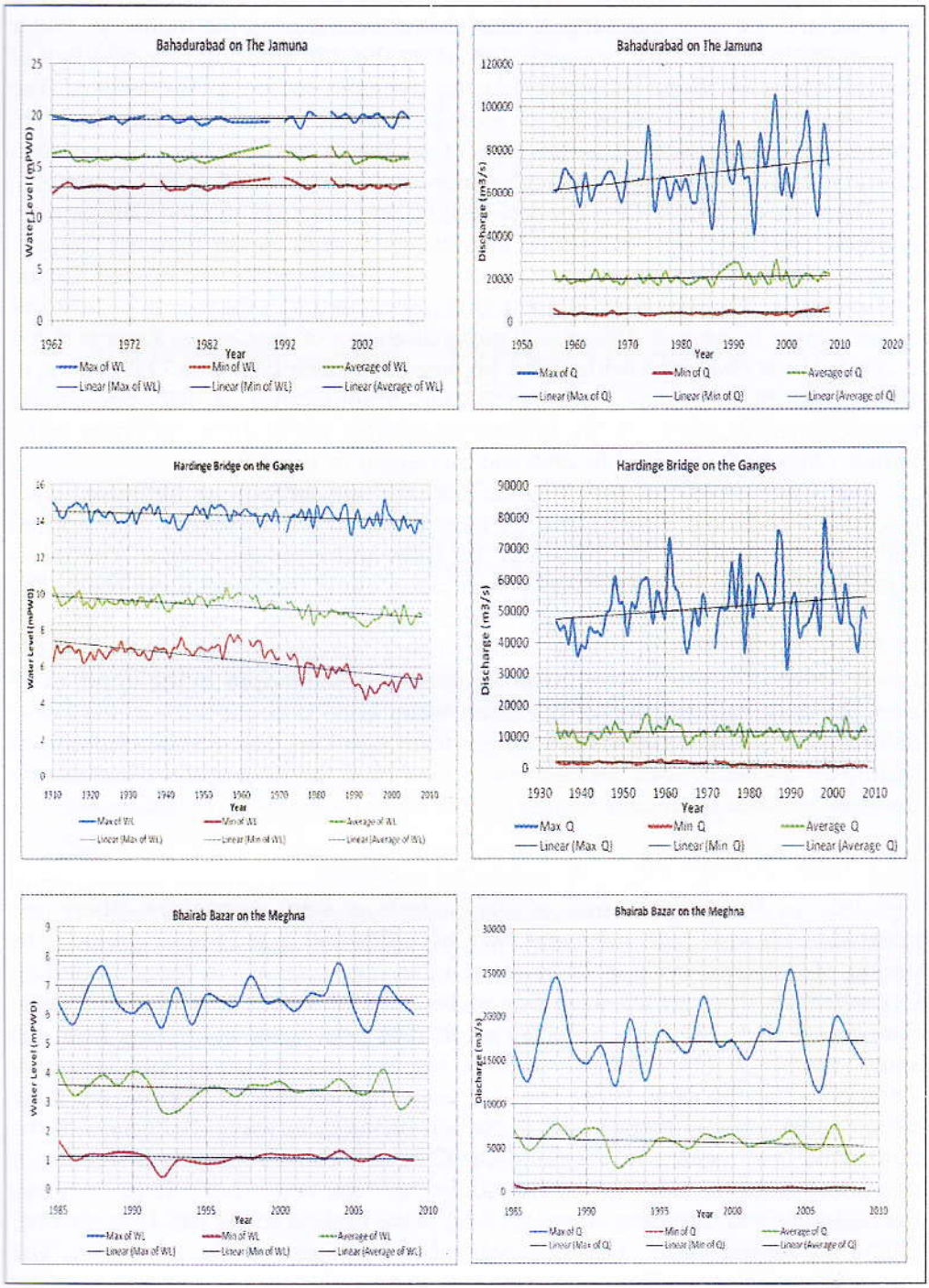

Figure 2.2: Trend in water level and discharge of the Brahmaputra and Ganges

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.

There are distinct differences between the Brahmaputra and the Ganges river regimes. The Brahmaputra rises on average one month earlier than the Ganges, whereas flow recession in the Ganges river begins earlier compared to the Brahmaputra. The peak flow in the Brahmaputra occurs in the month of July and in the Ganges in August. The annual mean discharge of the Ganges River is about 11,500 m^3/s at Hardinge Bridge. The highest peak since 1934 was 79,000m^3/s, in 1998. The annual mean discharge of the Brahmaputra at Bahadurabad is approximately 21,000 m^3/s. The highest discharge in the Brahmaputra river in the period 1965- 2009 occurred in 1998 and amounted to 105,000 m^3/s.

The water levels in the Meghna Estuary are influenced by tides, river discharges (seasonal effects) and cyclone events (cyclone surge). The normal water level conditions are influenced by tides and river discharges. The mean water level shows a marked seasonal variation along the Bangladesh coast. The seasonal variation of the mean high water level (from dry season in October to March, to the wet season in June to September) decreases significantly along the Lower Meghna Estuary in southward direction. At Chandpur in the upper delta area, the seasonal variation of the mean water level is about 3 m. In the lower delta area, the seasonal variation ranges from 1 to 2 m. The variation is caused mainly by the changes in the fresh water flow from the river system, but also by the seasonal changes in air pressure.

2.3.3 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 hr 25 minutes. The tidal wave from the Indian Ocean travels through the deep 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 northern side of Urir Char is shown in Figure 2.3.

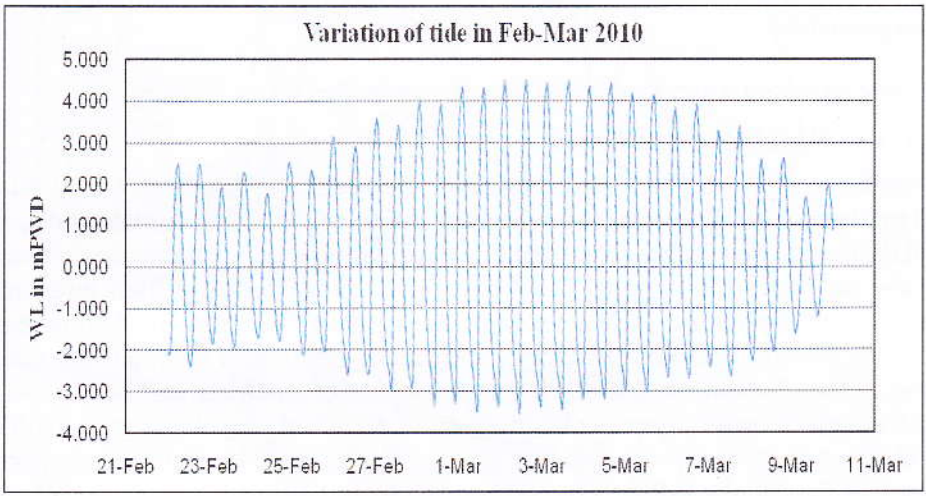

Figure 2.3: Variation of tide in the Meghna Estuary at north coast of Urir Char

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. In accordance with the classification of the tides proposed by Davis (1964), 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:	Hypertidal: Greater than 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 2000 and 2001, 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 Hatiya 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 FIFTY 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 main land 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 main land 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^2 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 km^2 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 Since 1973

Under Meghna Estuary Study (see Section 2.5.1), an estimate was made of erosion and accretion for the period 1973-2000, based on the analysis of satellite images. During this period 86,366 ha (863.66 km^2 were eroded, while 137,168 ha (1371.68 km^2) were accreted. The net accretion was 50,802 ha (508.02 km^2), which is equivalent to the net accretion rate of 18.8 km^2 per year.

Recent experience of natural erosion and accretion in the Meghna Estuary area i.e. during 2001-2008 is important in the perspective of land reclamation. Accretion is the dominating process during this period and the rate of net accretion is approximately 25 km^2/yr. Figure 2.4. depicts the erosion and accretion in the period from 1973 till 2008.

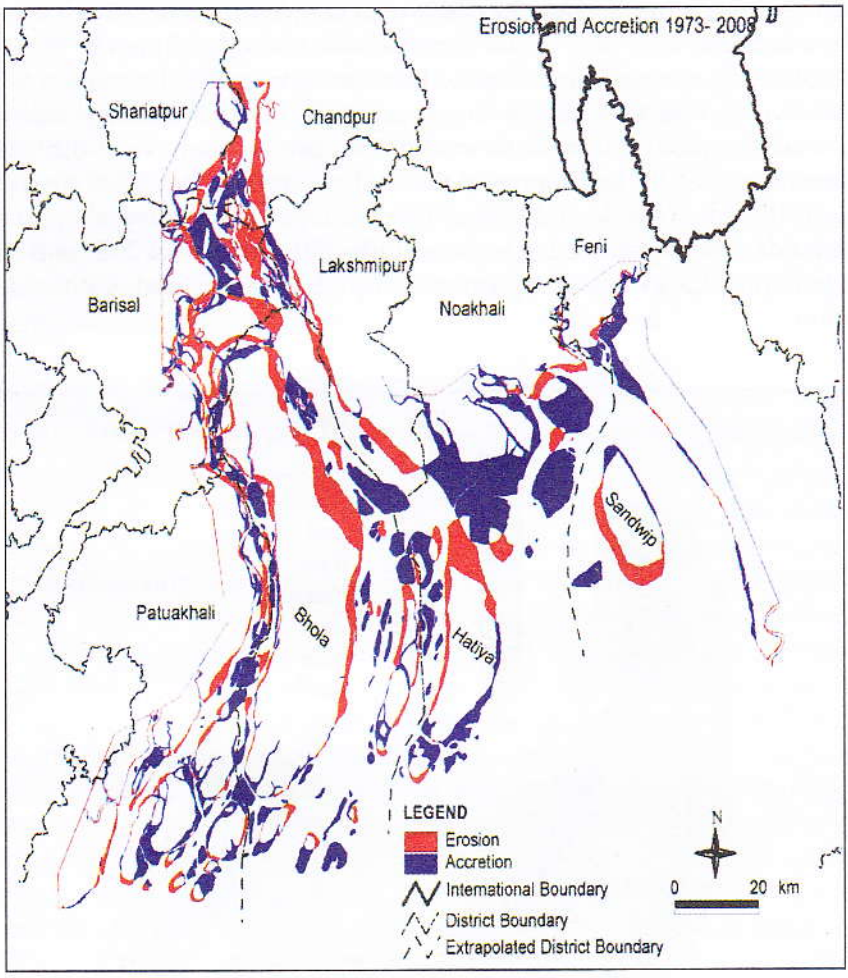

Figure 2.4: Erosion and accretion in the Meghna Esturay during 1973-2008

The accretion dominated around islands south and south-east of Noakhali mainland, 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.

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 kilometres) intertidal mudflat makes the demarcation very difficult and uncertain. Moreover, the boundaries of the land or intertidal mudflats are changing continuously. This also adds additional complicacy in delineating shorelines.

The landcover map extracted from analysis of the images of 2008 and 2001, as shown in Figure 2.5, gives a composition of water, mudflat, land, sand and dense vegetation.

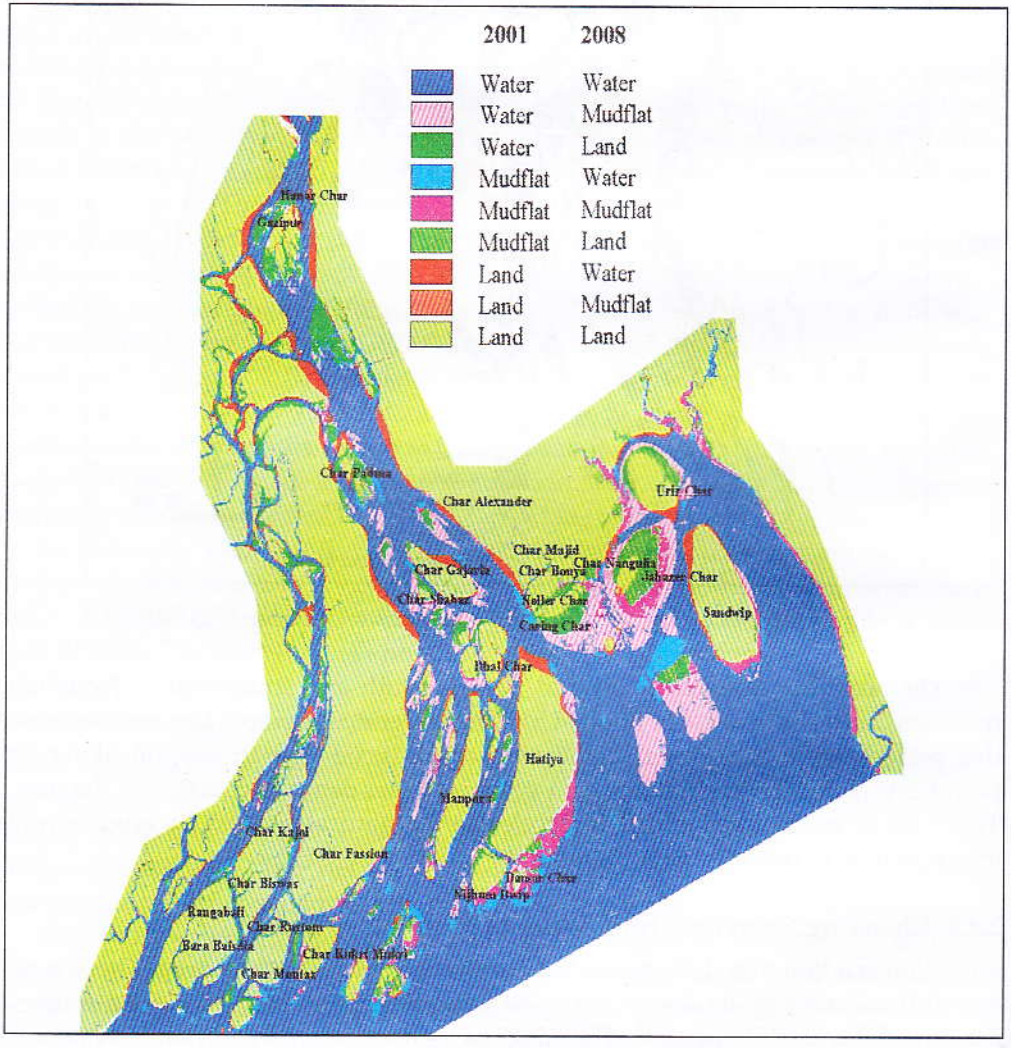

Figure 2.5: Land use and land cover change map between 2001 and 2008

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 hectare (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 hectare 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 Programmes in the Estuary

Over the years, the Government and development partners have recognised 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 will help to protect 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. 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. 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 programme 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 programme, the Estuary Development Programme (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 Figure 2.6.

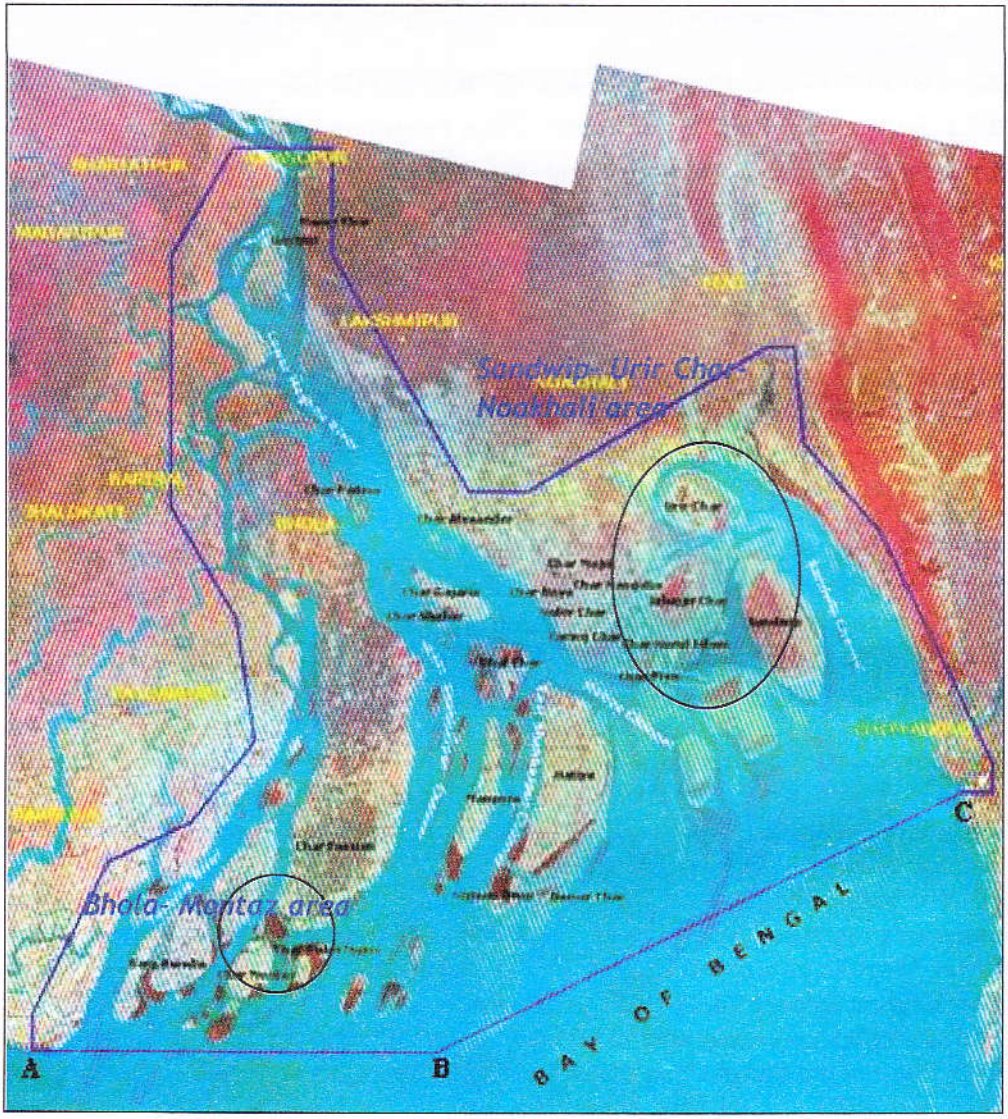

Figure 2.6: Project area Estuary Development Programme (Meghna Estuary)

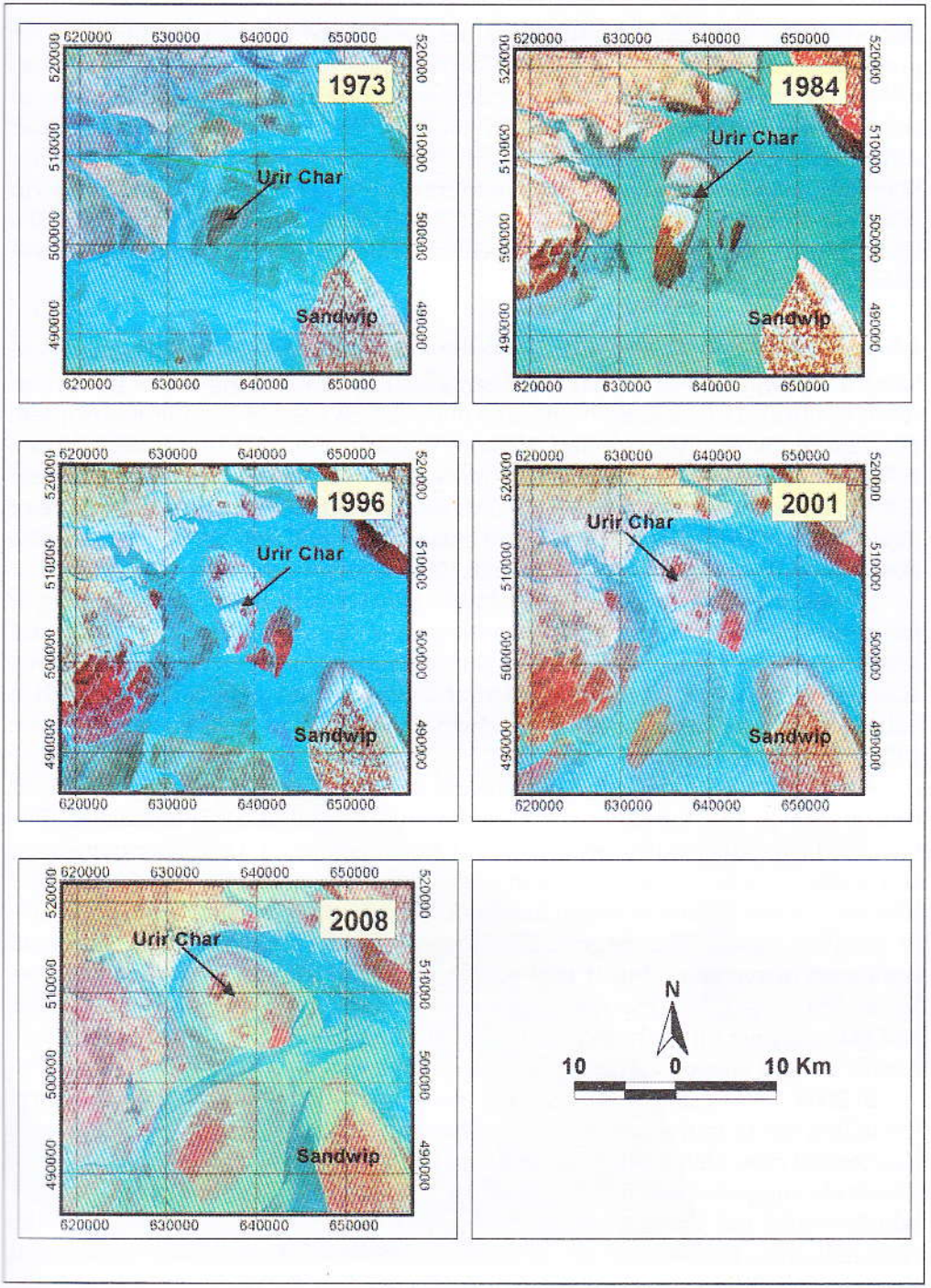

Figure 2.7: Development of Urir Char and surrounding areas

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 2.6) and Sandwip -Urirchar-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.

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 km^2/yr during 1973-1984 and later during 1984-96 the rate slowed down to 0.6 km^2/yr. From 1996, the rate of enlargement of Urir Char increased again to 2.85 km^2/yr and from 2001 the prevailing rate of increase was 2.45 km^2/yr. If the present enlargement of Urir Char continues in the near future, its area would be more than 125 km^2 within the next 10 years.

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 kilometres 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 1973 and 2008, is shown in Figure 2.7.

Accretion was the dominating process during 1973-2008 (see Figure 2.4). It contributed to the formation of a continuous mainland at Subarnachar. 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 was 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 modelling 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 km^2 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).

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. Proposals for implementation of Char Islam-Char Mainka, Char Mainka-Char Montaz, and Hatiya-Nijhum Dwip cross-dams have also been submitted to the Government. These land reclamation activities are in line with the Five year Strategic Plan of BWDB (2009-2014).

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, mainly in order to accelerate the stabilisation 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

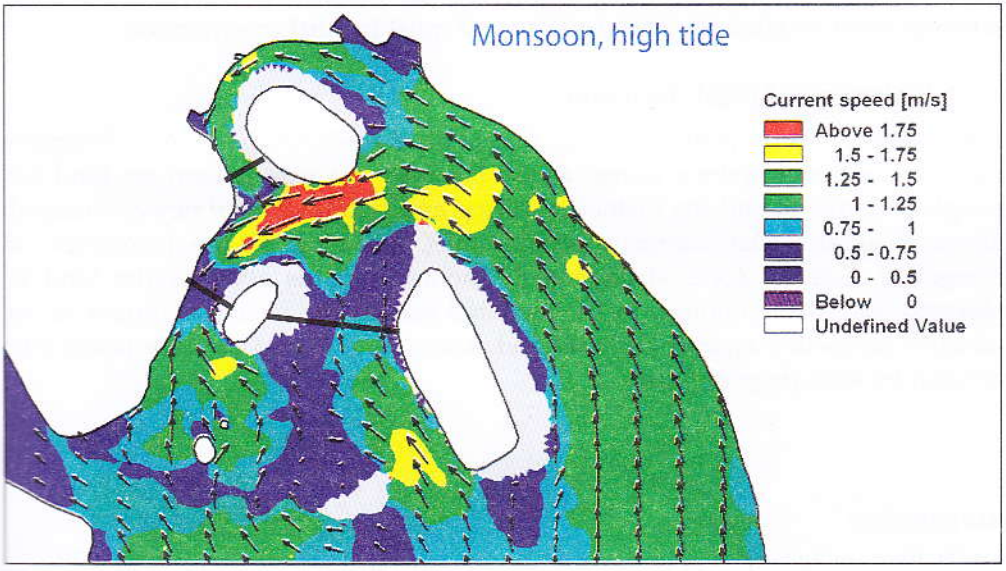

Figure 2.8: Location of cross-dams between Urir Char, Noakhali, Jahazer Char and Sandwip at tidal meeting points

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 accelerated 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

2.7.1 Monitoring

Monitoring of the coastal area generates valuable information on the dynamic physical processes that shape the estuary. Moreover, it is instrumental to update and fill the knowledge gap in order to provide timely assistance to devising coastal development programmes. 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.

2.7.2 Engineering Interventions

Engineering interventions as closing off waterways 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 programme for such schemes must be taken up with priority and must be further expanded.

2.7.3 Follow-up of Land Accretion

Activities aimed at accretion of land, should have a follow-up in a well designed land management system, aimed at serving both the requirement for land for people to settle on and the further maturing and stabilisation of newly emerged areas. Integrated development programmes, 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 programmes.

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Chapter 3

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

Dr. Bart Peerbolte, Md. Hasan Zubair

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 Forestry Department has the control in the newly reclaimed areas. Only after a period of 20 years this is transferred to the Ministry of Land. However, in reality premature settlement often evolves, 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 20 year period 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 (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 (Section 3.3). In case the choice is made to built a polder, the required infrastructure has to be identified (Section 3.4). With a polder, a number of issues are essential for the successful implementation and for its sustainability (Section 3.5). Operation and maintenance are crucial for the sustainability of structures in polders and unprotected areas (Section 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 IN DECISION TO LEAVE AREA UNPROTECTED OR TO 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 the 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.

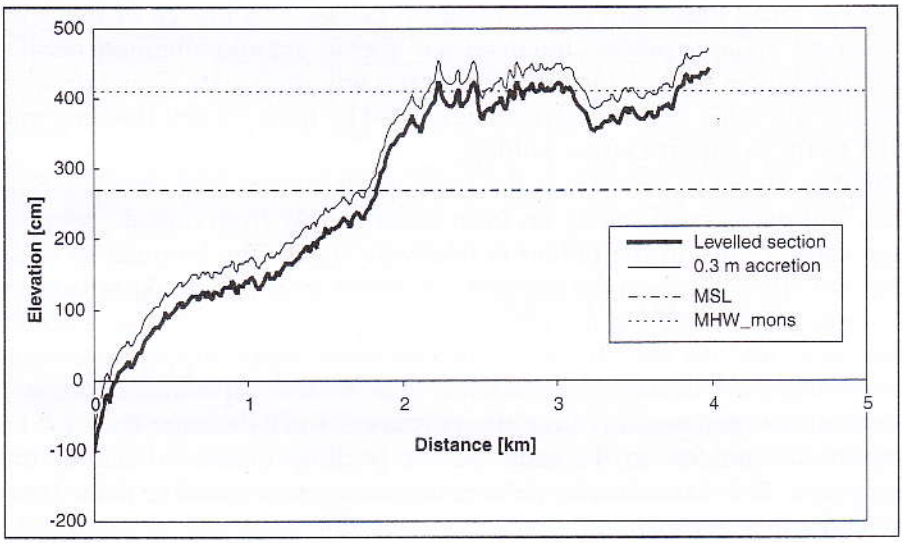
The implication of the above is that tidal water levels should be known in the area of empoldering. This is achieved by collecting water level data and, if possible, by connecting the tidal gauges in the project area to a nearby established tidal station such as a BIWTA tidal gauge. By combining the 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 levelling 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 levelling 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 levelling 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 empoldering. 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 figure 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 empoldering 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 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 favourable (=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 compartmentalise 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 the fresh water supply (see also 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 compartmentalisation 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 programme can be drawn up under the more formal EIA procedure (Environmental Impact Assessment). The EIA usually forms a part of a feasibility study. As a particular point of attention is 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 changes 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 *khals* 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 SUITABLE FOR 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 has, for instance, happened in the preparation of the next, fourth, phase of CDSP, when Caring Char was left unprotected for the next seven years or so, 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 drawn out in one direction). 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.

The interventions in CDSP–II took place in the following unprotected areas in Noakhali District: Char Mora Dona, Gangchil-Torab Ali, Char Lakshmi, and the eastern and southern part of the island Nijhum Dwip. In all these places a programme of cyclone shelters, deep tube wells, earthen roads, culverts and single pit latrines was implemented. In some areas canals were re-excavated. In the Gangchil area an experiment was done with a low embankment, which failed. The damage to the embankment due to floods was so great that the experiment was discontinued. Also earthen roads suffered more from floods, especially during monsoon time, than roads in empoldered areas. Consequently higher allocations for road repair have to be taken into account for unprotected areas. The same applies to re-excavation of drainage channels.

3.4 POLDER DEVELOPMENT: THE INFRASTRUCTURE

The main elements of infrastructure of a polder are the embankments (Sections 3.4.1 and 3.4.2), the drainage system (Section 3.4.3) and the intake/outfall structures (Section 3.4.4).

3.4.1 Position of Embankments

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.

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 agricultural benefits with 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 considerations the safety of the inhabitants of the polder should be taken into account.

3.4.2 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:

- 1:20 years flood where agricultural damage is predominant;
- 1:100 years flood where loss of human lives, properties and installations are predominant; this holds, in general, for embankments along the Jamuna, Padma and Meghna rivers.

Obviously, at the early stage of polder development agriculture is the main sector of economic activities. Therefore, following the BWDB design rules, a 1:20 frequency can be chosen. However, the BWDB rules are not necessarily compulsory. The CERP-II project proposed (December, 2000) to classify

embankments as follows:

- Class I: high protection
- Class II: intermediate protection
- Class III: basic protection

In addition a distinction is made between sea-facing, river-facing and transition embankments, the latter forming the transition between the first two mentioned.

The proposed water level return periods are as follows:

	Class I	Class II	Class III	Remarks
Sea-facing	> 20 yrs	15 yrs	10 yrs	Storm surges
River-facing	> 25 yrs	20 yrs	10 yrs	Monsoon river flows
Transition	Combination	Combination	Combination	Combination

A freeboard height should be added to the above design levels to count for wave run-up (normally on the basis of the 2% wave height of a design storm), wind set-up (if not included in the water level statistics for the above design levels), settlement and desired safety margin. In general, a minimum value for the freeboard is applied, viz. 5 feet for sea-facing embankments and 3 feet for river facing embankments.

In a later design stage a more detailed procedure may be followed to determine the required crest elevation, accounting for sea-level rise, local subsidence, settlement of the structure and the subsoil. Also the stability of the dyke will be evaluated at that stage.

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
Transition	Between	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 countryside 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 a borrow pit is necessarily to be placed 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 realised 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 unfavourable than higher land. Moreover, when a low-crest embanked 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 outside the 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.

3.4.3 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.

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 Section 3.4.4.

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. Intervention measures to rehabilitate the drainage function may be required then, the cost of which is to be included in the overall economic evaluation.

3.4.4 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.

Different functions of a drainage outfall structure:

- 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. Detailed monitoring of siltation of the Bashkali Khal—the drainage outfall channel of Char Majid—has been undertaken in 1999/2000. 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.

In general tidal motion causes sedimentation in the drainage outfall channels in the dry season. Silt bars form, the channel profile narrows and quite often sediment blocks 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 (organised by WMOs) to do the clearing of silt.

3.4.5 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.

3.5 ISSUES RELATED TO POLDER DEVELOPMENT

3.5.1 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. It seems that at Char Bhatir Tek such levels are reached earlier than at Char Baggar Dona and Char Majid. The peak 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 *khals* contain little water. Therefore, evaporation certainly contributes to the measured high rates of salinity.

Groundwater salinity is 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 are close to zero throughout the dry season. They 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 to sample in the tidal water which 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 analysed. 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, 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 *khals*. Fresh water ponds are wide-spread in the coastal communities. Analysis of the water use from such ponds indicates unaccounted water losses, 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 resalinisation 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.

3.5.2 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. Although the progress in knowledge is leading to varying scientific predictions of sea-level rise, a climate-induced sea-level rise between 5 and 10 mm per year does not seem unrealistic. Adding geological subsidence, a rate of 1 to 1.5 m per century is not unrealistic as scenario for the sea-level rise relative to empoldered areas (see also Chapter 11).

3.5.3 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 desalinisation 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) resalinisation 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 desalinisation 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 resalinisation 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 analyse the desalinisation potential of the envisaged areas. This can be done by comparative analysis, using data on desalinisation of similar areas. The CDSP polders start to show a stabilisation 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.

3.5.4 Socio-Economic Issues

A description and analysis of the socio-economic conditions, the type and degree of social organisation (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 at 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 realisation 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 substituting 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.

3.6 OPERATION AND MAINTENANCE

3.6.1 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 *khals* 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 organised (see Section 3.6.2.)? What does it cost and how it can be paid (see Section 3.6.3.)?

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 *khals*; 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 arguably 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, organising O&M and indeed undertaking maintenance become is difficult than elsewhere.

3.6.2 Organisation 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 organisations, of which the Water Management Organisations 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 project 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 Organisation 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:

Operation responsibilities

Implementing Agency (First Party)	LGI (Second Party)	WMG/WMA/WMF (Third Party)
• Operation of main hydraulic structures in discussion with 2nd & 3rd Party • Observe and inspect operational procedure of medium hydraulic structures with 2nd and 3rd Party and provide technical advice for proper operation	• Take part in the operation of main structures in discussion with 1st and 3rd Party • Observe and inspect operational procedure, process and necessity for operation of all medium and minor hydraulic structures and advice for proper operation to 3rd Party	• Take part in the operation of main hydraulic structures with 1st and 2nd Party • Operation of all medium and minor structures as per requirement of stakeholders • Develop operation plan as per requirement of stakeholders

Maintenance responsibilities

Implementing Agency (First Party)	LGI (Second Party)	WMG/WMA/WMF (Third Party)
• 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 1st 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 UP
Feeder road, rural road	Periodic	LGED
	Preventive	UP & WMO
Bridges, culverts	Periodic	LGED
	Preventive	WMO and 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 finalised 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 16 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 will be signed at the end of 2010. There will be agreements with both BWDB and LGED. This is probably the best model, to be followed in future programmes as well.

3.6.3 Costs

The Bangladesh Water Development Board

Since its start in 1959, BWDB has implemented about 710 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 cost of around 126 major projects including some riverbank protection projects is Tk. 15,180 crore (one crore equals 10 million).

The total value of the investments of all BWDB schemes combined 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.

The table gives an idea about the O&M funds available for BWDB and the corresponding expenditure during the period 2003-2004 to 2009-2010 (source: BWDB).

Table 3.1. 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

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). 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) programme 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.

3.6.4 O&M in Future

In future coastal development programmes, 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 programmes.

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.

3.7 CONCLUSIONS

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

3.7.1 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 to 1.5 m per century can be adopted as scenario for the sea-level rise relative to empoldered areas.

3.7.2 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.

3.7.3 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.
- There should be more clearance between the flap gates and the stop log grooves. The stop logs can be used then as a silt barrier in the dry season in order to prevent the accumulation of sediment against the flap gates.
- Possible simplification and improvement of the robustness of the hoisting mechanism of the lifting gates and the hinges and sealing of flap gates

3.7.4 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.

3.7.5 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 *khals* 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.

3.7.6 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 WMC 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 jeopardise the drainage capacity and not to cause drainage congestion. The maintenance should be based on the WMC-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

In Bangladesh, operative policies most relevant to the management of coastal forests are the Environment Policy (1992), Forest Policy (1994) and Coastal Zone Policy (2005).

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) emphasises 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 programmes, 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 T. 80,000 million for the period of 1995-2015 was formulated and approved. Accordingly different programmes have been undertaken. Amongst other measures, the Master Plan provides guidelines to take up massive people oriented plantation programmes both on government and privately owned land.

Regarding coastal forest, the Coastal Zone Policy (2005) has a similar commitment. It generally emphasises 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 programmes, 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 programme on afforestation and reforestation under the theme "Mitigation and Low Carbon Development." It supports new coastal afforestation programmes, 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.

The Forest Department is mainly responsible for plantation establishment and policy implementation to protect forests. Other institutions involved are the local administration of the Ministry of Land, the District Administration, the Local Government Engineering Department (LGED), the Bangladesh Water Development Board (WDB) and NGOs. One can observe an increased role of community based institutions as for instance Social Forestry Groups and Water Management Organisations.

4.2 FUNCTION 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 programme in the coastal zone would increase the forest cover that can act as carbon sink. The BCCSAP of 2009 emphasises 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 stabilisation 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 programmes. 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.

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 programme has been established since 1960-1961. 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 raising about 177,000 square kilometers of mangrove afforestation over the last five decades along the coast and on offshore areas, mostly in the central part of the coastal zone.

The table below shows the achievements till 2010. 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. Division	Total plantation (km^2)	Failed plantation (%)			Net plantation (%)
		Eroded	Encroached	Total	
Noakhali	705	21	14	35	65
Bhola	371	33	5	38	62
Patuakhali	243	9	1	10	90
Chittagong	454	25	14	39	61
Total	1773	23	10	33	67

The plantations were implemented under the following Forest Department schemes:

1. Afforestation in the coastal belt and offshore islands (1960–1961 to 1964–1965).
2. Afforestation in the coastal belt and offshore islands (1965–1966 to 1969–1970).
3. Afforestation Project in the coastal regions of Chittagong, Noakhali, Barishal and Potuakhali (1974–1975 to 1979–1980).
4. Mangrove Afforestation Project (1980–1981 to 1984–1985).
5. Second Forestry Project (1985–1986 to 1991–1992).
6. Forest Resources Management Project (1992–1993 to 2001–2002).
7. Extended Forest Resources Management Project (2002–2003 to 2003–2004).
8. Coastal Green Belt Project (1995–1996 to 2001–2002).

9. Coastal Char Land Afforestation Project (2005–2006 to 2009–2010).
10. Management Support Project for Sundarbans Reserve Forest (2005–2006 to 2009–2010).

The success of these programmes is highly variable. In cases of less successful endeavours, 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. If these specific problems are solved, the area of mangrove forest will be increased in the coastal zone. An extensive feasibility study could be done to find out the land suitability for mangrove afforestation in the whole coastal zone of Bangladesh.

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 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 1 m x 1 m 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

The species planted in the social forestry programme 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 stabilise 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 programme. 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 feet x 6.5 feet (about two meters) spacing, which means that in case of one kilometre 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.

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 programmes 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 programmes proved, however, that the 'trickle-down' process was not working and would not work. One of the earliest institutional responses to this realisation was a programme 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 recognised 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, utilisation 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 Centres; 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 realised by the promotion of coastal tree planting activities among the local population with the involvement of non-government organisations (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 recognised environmentally degraded zone.

The social forestry programme has been institutionalised through reorganisation 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 the forest extension division for the growth and distribution of seedlings, a gradual expansion of activities has taken place. In the reorganisation 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, and 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 Centres and 341 Social Forestry Plantation Centres. 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 programmes was arranged under different projects and schemes. In the beginning, participation of the local people in plantation programmes 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 (1981-1982 to 1986-1987) to Forestry Sector Project (1997-1998 to 2005-2006) 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 groups should have between 12 and 15 members. The members should form a part of the scheme's original labour 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 NGO's are selected and recruited for the selection of participants, their training and motivation. With the help of Union Parishads, local forest officials and NGO's 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. After that a participatory Benefit Sharing Agreement (PBSA) among the parties, including Forest Department (the Divisional Forest Officer is the main party for 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 NGO's are not available or provisions of NGO's 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 programmes. 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 Participatory Benefit Sharing Agreement (PBSA) is signed between the Forest Department, NGO's 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 4.2.

Table 4.2: 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 organisations 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	10% 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–III

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 organised. 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 4.3: SFG formation in CDSP–III (as on 30th June, 2010)

Name of the Activities	Nos. of SFG	Male members	members Female	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	1141	3030

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 we have largely ignored that attribute in devising mangrove management programmes. 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 programmes. These programmes 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 CONCLUSION AND CONSIDERATIONS FOR FUTURE COASTAL DEVELOPMENT PROGRAMMES

4.7.1 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, 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 programme should have a forestry component, based on social forestry principles.

4.7.2 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 4.4.

Table 4.4: 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
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. A separate study could be undertaken into the possibility of expanding the area with social forestry schemes in the coastal zone alone.

4.7.3 Funds Required for Mangrove Plantations

The suggested study to assess the amount of land available for mangrove plantations in the coastal zone, 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.

4.7.4 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 stabilisation 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. If people can be convinced that mangroves are important for their future livelihoods through land stabilisation 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

4.7.5 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 programmes should be developed. The function of forests in strategies to address climate change should be the main topic in such programmes. 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

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 two feasibility studies of the sector in the so-called new chars (Char Nangulia, Noler Char, Caring Char) and of Urir Char, conducted for the Char Development

and Settlement Project in 2006 and 2008. Attention is subsequently given to coastal fisheries, inland fisheries and aquaculture. Then the chapter describes work carried out by 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.

5.2 COASTAL FISHERIES

An important minority of the settler population in the new chars makes its living from marine fisheries. There are three main fisheries being practiced: offshore fisheries for *hilsa* and other fish species, especially the small goby, *chewa*, practiced by a minority of families, but important in economic value (Section 2.1); 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 (Section 2.2); and inshore crab catching, carried out only by a small minority, but of growing importance as an export commodity (Section 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 new unempoldered chars of Char Nangulia, Noler Char (including Patar Char and Char Rahman) and Caring Char. It is difficult to identify the total number of fishermen in each of these chars since most fishermen are well aware of the existing 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 and Char Rahman adjacent to the Hatiya river. Finally, in Char Nangulia, some 5-8% of households are fishermen, 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.

The fishermen in these new chars are mostly migrants from Hatiya. Before migration from Hatiya, they were involved with fishing in Hatiya channel in the Meghna estuary some 10-20 km offshore from the island. 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 fishermen go to the mouth of the Bamni and Feni rivers to the north.

Different fish and 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). *Chewa* fishes are sold to depots without drying. There are opportunities to catch other fish species like *Pangas, Bata, Ricksha* and *Gulla* all round the year.

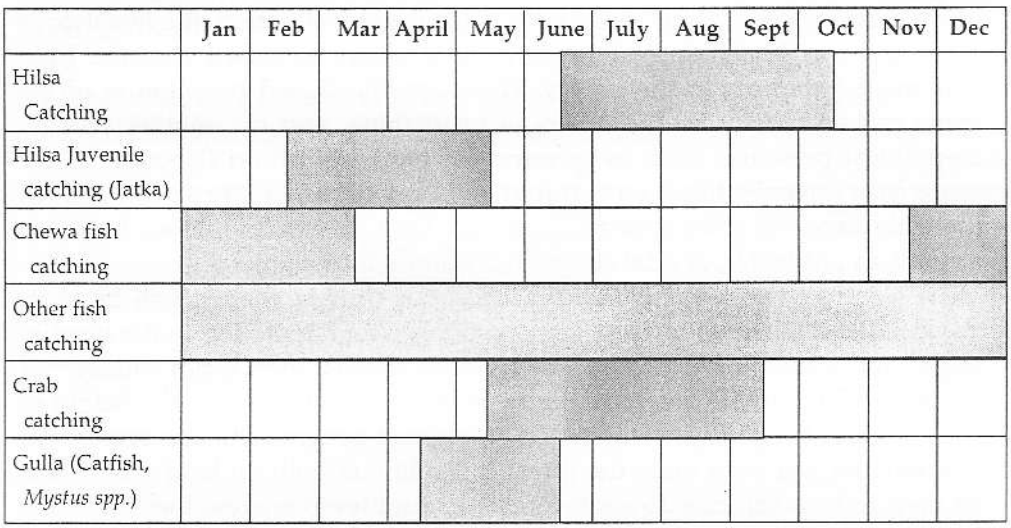

Figure 5.1: Seasonal calendar of fishing activities in new chars

Most fishermen don't 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 *dadunders* (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 boat and net) to the moneylender/depot holder.
- Sharing of profit with 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. These 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 in 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 present situation, the livelihoods of these inshore fisher households are coming under increased pressure from environmental changes in the fishery. This is partly caused by siltation of the Meghna estuary, partly by the effects of overfishing, and for another part by socio-political pressures such as government bans on certain fisheries, as for instance *jatka* (juvenile hilsa) and shrimp and prawn post-larvae catching. 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 a 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 polders 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 analyse 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. Out 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 household works. Most PL are caught during the night tides. Most people assume that a larger amount of PL could be caught on the night tide than

on the daytime tides. Adult males (mostly) catch PL at night and then go for work (as labourers) in the day. If PL are widely found available both day and night, they become involved full time in 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 7 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. Out of these three months, April and May are the peak. Most PL are caught during the full moon and the new moon, when the tidal effect is higher. Catching behaviour differs between the two species; *Bagda* are caught during the high tides and *Golda* during the low tide.

	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Golda PL catching				Peak time								
Bagda PL catching	Peak time											Peak time

Figure 5.2: Seasonal calendar of Golda and Bagda PL catch

PL is 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* purchased nets from markets in the upper chars by cash. During PL catching, 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 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. So they need to be involved in PL catching for their daily income. If the ban on PL catching were strictly enforced by the Government of Bangladesh, 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 mainly 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 rivers and canals using a rod made of iron with a curved headed, 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, today 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 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 (*Arot*) in Subornachar, Companigonj 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 *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 5.1 (prices of 2009).

Table 5.1: Crab grading and grade wise price

Grade (gm./pc.)	Price (Tk./pc.)
400	30
300	15
250	12
180	10
150	8
120	4

5.3 INLAND FISHERIES

Apart from the coastal fisheries, households in the new chars are also engaged in catching fish in the numerous *khals* (canals) which cross the new lands. Every household has small or large fishing gears (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 *khals*. Because these are becoming shallower because of 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 Tk. 100 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 *khals* 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 *khals* are used for local institutional developments (mosque, schools, Madrasa etc). Local committees look after the leased *khals*.

In Urir Char the number of canals is rapidly decreasing due to siltation, non-excavation and encroachment. Over the last five years half of the *khals* were lost. Only nine are remaining. With the approval from the Upazila Parishad, the Union Parishad leases out all *khals* on a yearly basis through open tender. In 2008, the

lease amount was Tk. 127,000 for the four canals in the south of the island and Tk. 8,000 for the 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 *khals*.

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 characterised 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* cropping (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. These ponds are not used for aquaculture but for trapping wild fish. People excavate the ditch with their own labour. This is the dominant type of pond in chars that are still maturing as Caring Char and Patar 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 labouring. These ponds are mainly found in Patar 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 snakehead (*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 – Ditch/ponds with crops-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 labour. 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 labour. The size of this type of pond varies from 20-50 decimals. They 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 5.2 summarises the general differences between these four types of pond described above.

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 the water resources. 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.

Table 5.2: Summary characteristics of different types of pond in the new chars

Particulars	Pond Type-1	Pond Type-2	Pond Type-3	Pond Type-4	Remarks
Dyke status	No dykes	Broken/incomplete dykes	Ditch/ponds with crops -land surrounded by dykes	Well protected dykes	Gradually raising the dykes
Range of pond size (decimal)	4-10	8-15	20-50	20-50	Annually increasing the size
Water retention period (month)	3-4 months (Up to October)	3-5 months (Up to Nov.)	4-6 (2 months in crop-land, up to Dec.)	6-8 months (up to Jan-Feb.); very few retain water around the year.	Including rainy season
Culture strategy	No stocking	No stocking	Traditional (Wild-Polyculture)	Traditional Carp-poly culture	Technically weak
Cultured species	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, Tilapia, Bighead, Grass carp, Puti,	Without management
Prawn culture	No	No	No	Very few households stock prawn	Results in prawn culture good
Fry/fingerling source	No stocking	No stocking	Upland (fry traders/Patilwala)	Upland (fry traders/ Patilwala)	Lack of quality fingerling
Feeding	No feeding	No feeding	No feeding	Little use	Only rice-bran used
Marketing	Used for household consumption	Used for household consumption	Mainly household consumption; rests are sell.	Sell to the local marke t and use for household consumption	Local market price low
Flood affection	100% affected	100% affected	Combination of affects from rain and tidal surge (full moon, new moon)	Normally not affected; but exceptionally affected by tidal surge and flood	If improve drainage system it will be reduced

(contd.)

(Table 5.2 contd.)

Particulars	Pond Type-1	Pond Type-2	Pond Type-3	Pond Type-4	Remarks
PL nursing	No	No	No	No	Not aware
Dyke cropping	No dyke	No	Rabi cropping (winter) in area surrounded by dykes	Tree plantation/ cropping practiced	Good production from cropping
Average depth of pond (Range in ft)	4-6 ft	4-8 ft	7-10 ft	10-15 ft	Annually increasing depth
- Objectives of pond excavation	- Soil used for house-base upgrade - Bathing, cooking and washing	- Soil used for house-base upgrade - 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 - Household use - Few ponds dig a well to keep water for a long time in the pond	Tendency to excavate a well in the pond to retain water for longer

Aquaculture in Bangladesh, in particular 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 ensured 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 fertilisation, stocking with an appropriate mix of species to use the different ecological niches in the pond and at the right density, judicious feeding and fertilisation during grow-out, maintenance of a good pond environment and multiple harvesting to ensure efficient utilisation 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-aid projects. Although there have been a number of government funded projects, including one offering credit for poverty alleviation activities in aquaculture, there is a 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 channelled through large national NGOs such as CARITAS and BRAC, both of which have their own specific fisheries programmes.

Role of Danida

An important part of this early work on carp polyculture systems 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 the 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 project covered 15 Upazilas in the three districts of Feni, Lakshmipur and Noakhali itself. Several of these Upazilas correspond to the charlands, notably Sonagazi in Feni District, Companiganj, Subornachar, Noakhali Sadar and Hatiya in Noakhali District, and Ramgoti and Komolnagar in

Lakshmipur District. GNAEP and its successor project, the Regional Fisheries and Livestock Development Component (RFLDC), have been and continue to be the key player in the development of aquaculture in the region. 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 continues 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 organisations (NGO). The NGOs also provided credit, without which it was assumed 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 programme 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.

(a) 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 in paddy fields in the chars, known in Bangladesh as *gher* farming
- Development of improved aquaculture in community ponds in cluster settlement villages developed under CDSP

- Development of carp and prawn nurseries in small-seasonal ponds developed by poor households from raising the homestead platform in areas subject to flooding
- Cage culture in rivers and in multiple ownership ponds
- Aquaculture in the rainy season in waterlogged paddy lands

Apart from the latter 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 the ponds of 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 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.

(b) Role of the private sector: GNAEP's success in widening the aquaculture options and increasing the value-added, 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.

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 which enabled sale of post-larvae at a price of Tk. 1.25 per piece from 2002-6, only half the prevailing price offered by the hitherto dominant hatcheries run by the 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 Programme, a modern fish and prawn processing plant in the region. Altogether these private sector investments totalled over Tk. 200 million

(c) Promotion of farmers' organisations: The other key element of the support system was the development of community-based organisations. 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 organisation. Thus the post larvae, feed and other input supplies required for prawn farming were channelled to the farmers through the development of a network of community-based organisations (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

Although its duration was extended somewhat, the 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). Although widened in scope, the design and focus of RFLDC has continued to follow the approach begun under GNAEP. In particular the participatory learning approach developed under GNAEP has come into play. RFLDC is a part of Danida's Agricultural Sector Programme Support, Phase–II (ASPS–II). Under earlier phases of this programme, the Farmer Field School (FFS) approach was promoted successive projects of the Department of Agricultural Extension's Integrated Pest Management programme. Over time it has become the preferred training mode for the whole of ASPS–II, including RFLDC. For RFLDC, a target was set for 5,100 FFS in its 5-year implementation period. The RFLDC FFSs are integrated in scope, covering both fisheries and livestock and also include homestead gardening and nutrition issues. They are demand-driven in the sense that the curriculum is 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. Aquaculture is just one module in the Farmer Field School. Through 5-6 Learning Sessions conducted over a whole culture season, farmers analyse the potentials of their aquatic resource systems, whether household or community-based, and determine through exchange of experience and on-system trials what technologies are suitable for them. Inevitably these Learning Sessions incorporate such issues as pond preparation, choice of suitable culture species and stocking densities, feed and fertilisation, good husbandry, avoidance of risks and harvesting- and marketing strategies.

The Farmer Field Schools are conducted by young men and women (40% of the total are women) chosen from farming households in the local community for their communication skills and social acceptance. These young people, known as Local Facilitators, are trained by project staff in a four-month so-called Season-long Learning in which they learn how to run a Field School, facilitation skills and receive hands-on experience in the various technical issues to be discussed in the FFS. On this basis, they pass on their experience to the farmers. Given their often limited educational qualifications and farming background, it is expected that the Local Facilitators will stay in the community and practice themselves the new techniques discussed with the farmers.

Under RFLDC, the training through FFS is complemented in the provision of services once again by promotion of Community-based Organisations, many of them inherited from GNAEP. Most of the Farmer Field Schools are also organised by the Community-based Organisations, which ensures the provision of services in support of the FFS learning. The CBOs in turn receive support through links to private agribusiness and by a Block Grant facility offered to local government institutions. The CBOs can tap this facility for making further investments. Thus, in the aquaculture sector, the CBOs establish nurseries for fish and prawn to ensure that the seed of the right size can reach their members and clients in a timely manner. RFLDC has also trained Community Agriculture and Aquaculture Resource Persons (CAARP) in the CBOs through a similar practical Season-long Training to manage these facilities and to act as the key focal point person in the organisation to interact with the hatcheries and other input suppliers. The CBOs are clustered in District Associations which also make links on their behalf to private agribusiness. The Feni District CBO Association, for example, has commissioned a local miller to produce fish feed according to a formula set by the Association, which is then distributed through the CBOs.

At present, the nurseries include not only carp and prawn, but also tilapia. RFLDC has recognised that in the chars in particular, there is 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 favourable conditions in 2002-2003 and has proved more difficult to sustain in the years following because of drought and flood. Thus, RFLDC has encouraged the development of a private-sector tilapia hatchery in the chars, utilising sex-reversal techniques which ensure all male fish which grow rapidly in appropriately fertilized ponds.

RFLDC is also engaging with private agribusiness in attempting to improve the quality of carp seed. Deterioration of seed quality of Indian major carps through interbreeding and uncontrolled hybridisation between the three major species, *Rohu, Katla and Mrigal*, has now been recognised—also by farmers—as a major constraint on improvement of the productivity and profitability in aquaculture. Although the Department of Fisheries has begun the development of pure breeding stocks at major seed production centres such as Raipur, the problem is also to change the management system of private sector hatcheries in order to ensure that the improved seed indeed reaches the farmers. RFLDC has launched an adaptive research effort to this end in co-operation with the World Fish Centre Bangladesh and South Asia Office with the objective of certifying a number of local 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 increases to 58.1%, among which a very small proportion are rice field culture systems (*ghers*). A typical pond in this area is 26.1 decimals or just over 1,000 square metres. Such systems are mainly under a carp polyculture of *catla, rohu* and *mrigal*, although in some cases there has been a movement to stocking of tilapia. Typical stocking densities are 1.5 fry per square meter of pond surface.

Despite the presence of GNAEP in the area, the average yield in these systems remains low at just 5 kgs per decimal (1,250 kgs per hectare), of which 0.4 kg constitutes freshwater prawn, and sales of fish per decimal are 3.8 kgs, including 0.3 kg of prawn. Total income from the pond systems, excluding prawn, averaged Tk. 7,552 per household in 2006-2007. These yields are low considering the fact that over 80% of pond culture systems apply supplementary feeds mainly oil cake

and wheat bran, and over 60% apply urea fertilizer and/or cow dung. However, amounts of feed are small. The average application of organic fertilizer use per household is a mere 11 kgs., mainly on bi-monthly basis. There is thus substantial scope for raising productivity to the levels previously achieved by GNAEP and in the Mymensingh Aquaculture Extension Project.

The design of RFLDC is meant to address the limitations of the earlier extension approach, particularly its rather rigid technology-driven mode and the limited emphasis on sustainability. The Farmer Field Schools of RFLDC include a learning module on aquaculture comprising 6-7 learning sessions. These learning sessions are applied both to individual household ponds and to community ponds. But they should be designed with a degree of flexibility so that the participants learn to adapt the technologies to particular environmental contexts. This is also 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 and changes in water temperature. Although most species currently being cultured are reasonably tolerant of changes in water temperatures, there may be a need to adjust the species mix in relation to salinity, while flooding and water logging 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 is supported by inputs supplied through the CBOs. In Subornachar Upazila, the heart of the Noakhali chars, there is a network of 10 CBOs, the number of which increases as Farmer Field Schools are implemented in more isolated areas and form their own farmer organisations. The CBOs make proposals for development grants for nursery development as well as provision of inputs, with specific proposals being made for development of the community ponds.

As the new chars open up thanks to road construction activities by RFLDC's sister component in Rural Roads and Market Access Development (RRMAC), RFLDC is attempting to extend the same process to these areas. Already several CBOs have been established in the new chars, some of them based upon and widening out the activities of Water Users Groups established by CDSP. Several of these are already conducting their own FFS and carrying out a range of services. In other cases, RFLDC has 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 has already conducted 50 FFS and has started a further round of 30 FFS. In Char Nangulia, Upakul Unnayan Songstha has begun a similar process with 18 FFS. It is not yet clear whether the lack of secure land tenure in these areas will be a constraint to investment.

5.5 CONCLUSIONS

5.5.1 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. Important in this respect are 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.

Some fishers are able to compensate for the loss of the offshore fishery by trapping and fishing in the riverine tracts and creeks of the new and as yet unprotected chars. However, siltation is also affecting these resources. Projects for the stabilisation and empoldering of these chars by blocking the water courses and restricting the movement of the wild fish will inevitably lead to further decline in the inland fishery, just as has happened in the existing embanked chars.

5.5.2 Potential of Aquaculture in Chars

In these circumstances, aquaculture development is required. This has begun to take off in the more stable and empoldered chars, but productivity and returns remain low. There are considerable potentials for increasing the contribution of aquaculture to livelihoods, but to realise these potentials in the Noakhali chars three key issues must be addressed: appropriate interventions, the institutional basis for intervention and, probably, secure land tenure. There is a need to recognise 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.

5.5.3 Appropriate Interventions and Institutional Framework

There are clearly potentials for aquaculture development, in household ponds and in the various community aquatic resources that are being created by projects like the Char Development and Settlement Project and by government resettlement schemes. For these potentials to be realised, the suitable technical

interventions have got to be established, based upon the resources, 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.

5.5.4 Tenure over Land and Water Resources

Finally, 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' organisations seems promising. In relation to the third factor, in the Noakhali chars, RFLDC depends upon the efforts of projects like CDSP to ensure the appropriate land and water rights.

5.5.5 Impact of Climate Change

As mentioned earlier, climate change may be having an effect on the fishery at sea, through the increased incidence of stormy weather. As can be seen in Chapter 10, stronger boats will be needed to mitigate the consequences. With regard to inland fisheries, steps need to be taken to assist local communities in analysing their situation and in starting a process of adaptation to address 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 salinity. Flooding and waterlogging may require adjustments in pond design and a larger role for community-based systems.

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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 colonised 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 become what may be described as a 'walking bank balance' which also bears interest when the animals produce calves, kids and lambs.

Thus, where there is secure settlement, with large areas of adjacent grassland as yet unsuitable for human occupation, livestock rearing becomes an important dimension of livelihood. This is typical of Urir Char and parts of Char Nangulia in the unempoldered areas and for families living within the embankments where there are adjacent lands outside the dyke. This situation is typical of parts of Char Clark 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 Monpura island.

6.2 REARING SYSTEM IN THE UNPROTECTED CHARS

The Regional Fisheries and Livestock Development Component, Noakhali conducted a baseline survey during its inception period (2007). This survey

covered a range of different agro-ecologies throughout the project area. The project is operational in the Greater Noakhali area (the three Districts of Feni, Lakshmipur and Noakhali), plus adjacent areas of Chittagong District. The survey uses the standard classification of Agricultural Ecological Zones (AEZ) of the Soil Research and Development Institute (SRDI). The project area represents four zones. 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. Much of the data in this chapter is derived from the base line survey and from a feasibility study for CDSP (2008) for livestock development in Urir Char.

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. These figures are interesting when compared with a much broader area of Noakhali mainland. Here, only 33% of households were recorded as owning cattle, a mere 12% reared goats and less than 2% sheep. These figures rise slightly in the charlands of Noakhali (coincident with Agro Ecological Zone–18), but not markedly. Moreover, the number of large livestock per head for those families actually rearing, also falls, especially for large ruminants. Thus the average size of holding of cattle in the broader area is only 2.5 (three for the charlands). On the other hand, the average holding of a herd of goats is much the same at 2.1 animals. It would seem that in Noakhali as a whole the high population density and the consequent lack of grazing land becomes a constraint to rearing of large livestock (Tables 6.1. and 6.2.).

Table 6.1: Proportion of households rearing different animals (%)

Description	Noakhali				
	AEZ-17	AEZ-18	AEZ-19	AEZ-23	All
1. Cattle	23.8	39.7	36.8	27.5	33.1
2. Buffalo	–	0.8	–	–	0.3
3. Goat	8.8	18.7	4.4	6.6	11.7
4. Sheep	–	3.0	–	–	1.2
Any animal	30.0	49.0	39.0	30.8	39.5
N (All households)	273	363	182	91	909

On the other hand, rearing of poultry in the unempoldered chars and in the region as a whole appears to be quite similar. Over 81% of all households in the overall area rear chickens and over 63% ducks, the figure rising to 87.6% and

69.7% respectively in the Noakhali char land region. (Table 6.3). The average number of birds per rearing household is a little lower at 7 head (9 for the char lands) for chickens and just 5 head for ducks (Table 6.4).

Table 6.2: Average number of livestock per sample household among households rearing each type of livestock

Animal	Noakhali				
	AEZ-17	AEZ-18	AEZ-19	AEZ-23	All
Cattle	2.1	3.0	2.1	1.6	2.5
Buffalo	–	3.3	–	–	3.3
Goat	1.7	2.1	3.3	1.8	2.1
Sheep	–	10.4	–	–	10.4
Any animal	2.2	3.9	2.3	1.8	3.0
N (Those who rear)	82	178	71	28	359

Table 6.3: Proportion of households rearing different types of poultry

Type of bird	Noakhali				
	AEZ-17	AEZ-18	AEZ-19	AEZ-23	All
*Local Chicken	76.2	87.6	86.3	60.4	81.2
Farm Chicken	0.4	1.4	0.5	-	0.8
Duck/ Goose	57.9	69.7	67.0	45.1	63.1
Pigeon/ Other	2.2	8.5	5.5	1.1	5.3
Any of the type	83.9	90.6	90.1	73.6	86.8
N (All)	273	363	182	91	909

Note: *Include *Sonali* and *Fayoumi* chicken

Table 6.4: Average number of poultry per sample household among households rearing each type of bird

Description	Noakhali				
	AEZ-17	AEZ-18	AEZ-19	AEZ-23	All
1. Local Chicken	5.7	9.1	6.2	4.4	7.2
2. Farm Chicken	5.0	1320.4	500.0	-	1015.3
3. Duck/ Goose	4.2	6.0	5.0	2.6	5.1
4. Pigeon/ Other	9.3	6.0	5.7	4.0	6.3
Any bird	8.3	34.1	13.1	5.3	19.8
N	229	329	164	67	789

6.2.1 Borga System of Share Rearing for Ruminants

The wider distribution of livestock holdings in the unempoldered chars like Urir Char and Char Nangulia may be partly explained by the rearing system. All 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 taka. In the case of milch cows, the milk and the first calf are retained by the *borga* cropper. (S)he—and often it is a lady—receives a 50% 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 labour. It sometimes happens that the male member leaves the cattle and sheep at the grazing area while on his way to other work (day labour, 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 can not 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 specially prepared mounds called *"killa"*.

6.2.2 Bathan Operation

Some cattle, buffalo and sheep are reared in *"bathan"* systems, in large herds in open grazing land. Most *bathan* have their own *killa*, where animals 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*, 50-55 cattle *bathan* and 18-20 sheep *bathan*. A *bathan* typically ranges from 30-300 head of cattle, 50-200 buffalo and 100-200 sheep. About 75 individuals own these *bathans*. Half of the owners are from elite households in Sandwip and Companigonj Upazilas. There are a few smaller *bathans*, which have evolved and are managed by several families in partnership.

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 litre per day and for buffalo 3-4 litre 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 litre for cow's milk and Tk. 20-25 taka/litre 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 favoured 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. diseases are common for cattle and buffalo. Goats suffer from *peste de petits ruminants* (PPR) and 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 *bathans* 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

As stated above, 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 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 drinking 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 is 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 per *hali*.

The above description of the livestock system in the unempoldered char lands presents a somewhat static system, 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 charlands 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 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 unempoldered 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.

6.3.1 Large Livestock Rearing.

Animal breeds

Almost all the ruminants reared in the Noakhali char lands are local breeds. The RFLDC baseline survey of 2007 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 crossbred 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 natural bred animals, 80% of the households used stud animals from within the village. Others either used a source 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 (16%) and others (10%). For this act 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 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, 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 the 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 stall and grazing.

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.

Table 6.5: Nature of rearing by type and breed of cattle and goat (% of households by system)

Description	Noakhali				
	AEZ-17	AEZ-18	AEZ-19	AEZ-23	All
A-1. Local cattle					
1. Scavenging only	51.0	72.4	57.6	63.3	64.7
2. Closed/In house	43.0	10.7	40.4	23.3	23.8
3. Both ways	6.0	16.9	2.0	13.3	11.6
N	100	272	99	30	501
A-2 Cross-bred cattle					
1. Scavenging only	100.0	58.8	83.3	50.0	75.0
2. Closed/In house	–	35.3	16.7	50.0	22.7
3. Both ways	–	5.9	–	–	2.3
N	11	17	12	4	44
B-1. Local Goat					
1. Scavenging only	57.1	75.7	25.0	66.7	67.9
2. Closed/In house	32.1	2.8	58.3	33.3	14.1
3. Both ways	10.7	21.5	16.7	–	17.9
N	28	107	12	9	156

Note: * Cattle includes buffalo and goat includes sheep.

Animal health care

The productivity of large livestock in the char lands is 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. For cattle, the most frequent problems were Foot and Mouth Disease (31%), 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 the cases, the survey respondents regarded the disease outbreaks as severe or moderately severe.

In 92% of the cases of disease in cattle and 82% of the cases in goats, the respondents treated their animals. 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 the 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 the respondents claimed they had no interest in vaccination or saw

no need for it, an indication that most had not suffered a serious disease problem during the year. In fact only 19% of all households in the baseline survey said they had vaccinated their animals in the previous years, 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, by far 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" (sometimes trained by NGOs) 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 the 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 the households in the Noakhali region sold animals, almost 80% of them cattle. For these households, the cattle constitute a significant source of income, since those selling disposed on average 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-ul-Azha. 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 the 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 milk 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 litre per day, and that the price of milk in isolated parts of the chars is very low because of transportation costs. In 2007, the milk price was only Tk. 15-20 per litre, 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 markets.

6.3.2 Poultry Rearing

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 vast majority of households rear local (*deshi*) chicken. Remarkably few households rear 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. A slightly larger number rears 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%) operates commercial layer and commercial broiler farms. It should be noted that poultry rearing is almost exclusively carried out by the women in the household.

Breeds and rearing methods

Local birds are typically reared on scavenging basis (89% of rearing households), although it is interesting to note that in the Noakhali chars 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 and through the work of NGOs. However, confinement of the birds does not necessarily mean an improved diet. The only significant feeds given to poultry birds are rice, rice bran, paddy and some broken wheat, and maize. The feeds are pretty much the same for chickens and ducks (Table 6.6).

Table 6.6: 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	37.4
Crushing oyster/ouster	0.5	14.3	12.8	2.1	5.9
Feed Additives	0.4	–	0.2	–	0.3
Prepared Branded feed	–	85.7		–	0.4
Rice	92.5	–	86.2	33.3	87.3
Paddy	32.8	–	37.6	66.7	35.9
Number of households rearing	743	7	596	48	1394

Animal health care

The 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. The incidence of disease was 85% for local chickens and 50% for ducks and geese. The biggest problem in the case of local chickens 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; 46% and 50% respectively 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.

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). The vaccination for fowl pox (28%) and fowl cholera (17%) was much lower.

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 (an other sub-component of RFLDC is based on the western bank of the river Meghna) where self-treatment dominated. This demonstrates probably the positive impact of development efforts by the Smallholder Livestock Development Project and 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 the 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 was Tk. 635 per household.

6.4 DEVELOPMENT OF ANIMAL HUSBANDRY IN THE CHARS

The description of the livestock rearing systems in the Noakhali chars contained in Section 2 indicates that animal husbandry is a very important element in household livelihood in the unempoldered 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 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 declines. In the empoldered 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 is apparent.

Unfortunately, as the description in Section 3 demonstrates, the livestock rearing systems of the Noakhali char lands remain underdeveloped. 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 to date follow a curative strategy, seeking to treat their animals when they fall ill, rather than a preventative strategy, through improved husbandry and regular vaccination of stock. Particularly in the more isolated areas, access to veterinarian service is extremely restricted and farmers often treat their animals themselves or turn to an unqualified traditional *'dakter'* in the village. Hence, productivity is low. Beef cattle grow slowly and milk yields are 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 relies 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 that productivity is extremely low and livestock products (milk, meat and eggs) provide 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, 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 Centres (ULDC), which apart from the Upazila Livestock Office itself may contain an artificial insemination centre and a service for treatment of large animals. These Centres 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 vaccines. 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 kilometres 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 training events are organised 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 has, as with the Department of Fisheries, depended largely upon donor-funded projects. Since these projects have mainly emphasised 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 (Feni, Lakshmipur and Noakhali), as well as two Districts of Barisal Division. This project was scheduled to begin in 2000, ending in 2006. This Danida-funded project was the forerunner of the Regional Fisheries and Livestock Development Component, Noakhali, currently operating in the Noakhali chars. The main objective of this project was income generation for famers through increased and sustained productivity of backyard 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 Rearers) 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 *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 local (*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 (8 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 with semi-improved animals at the ratio of one male to ten 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 partly 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 question in relation to the poultry model appear rather to be whether the model with its dependence on the supply of external inputs, centered around 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 has led to the removal of the supply chains on which it depends. 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 Chicks for the Chick Rearers by limitations of the Government of Bangladesh system. The same can be said of the supply of vaccines for the Poultry Workers, both in terms of quantity of supply (not enough birds) and quality (high mortality during delivery, doubtful effectiveness of the vaccine because of the failure to maintain adequate supplies and because of the inadequate the cold chain). In the latter context, the regular supply of vaccines 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 environments 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 to increase the number of clutches to be reared in a year and (b) ensuring a regular supply of reliable vaccine. These two interventions would bring about a major increase in productivity from local *deshi* hens, rearing of which would also reduce rearing costs because of their lesser dependence on improved feeds.

The Regional Fisheries and Livestock Development Component (RFLDC)

As the successor project of SLDP–2, the Regional Fisheries and Livestock Development Component, Noakhali, has tried to build on its experience. RFLDC has incorporated poultry rearing in its Farmer Field Schools (see Chapter 5) where the key learning topic is how to improve the rearing of *deshi* chickens. Farmers experiment with testing out improved brooding technology, removal of the broody hen from the chicks at different dates and supplementary feeding. For the feeding they learn to use as much as possible ingredients available on-farm. Farmers also become familiar with the different diseases of poultry and the schedule for vaccination. The Farmer Field Schools provide the technology dimension; the Community-based Organisations (already discussed in Chapter 5) provide an institutional home for the Poultry Workers and thus help them to obtain supplies of vaccine.

Rebuilding the vaccine supply chain under RFLDC, Noakhali, has not been easy. It was quickly recognized that, in the absence of the NGOs, the CBO would have to play the role to ensure the supply down to the grass roots level. However, maintaining the cold chain to this level has required that CBOs and their District level CBO Associations need to invest in their own refrigeration facilities. RFLDC has supported this through the Block Grant facility it provides to the Union Parishad, for which the CBOs can 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, not enough supplies of vaccine are available and questions are being asked about the quality since the vaccine is sent down to Noakhali in cool boxes on normal service buses. This problem is most extreme in the isolated chars, where also the electricity supply is either erratic or non-existent. To ensure regularity and quality of supplies therefore, RFLDC has encouraged the CBO Associations to make their own arrangements to collect vaccines from the Department of Livestock Services production facility in Dhaka and, more recently, 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 has widened to include ducks, small ruminants, both goats and sheep, cattle fattening and latterly dairy farming. Where so requested by farmers, all of these types of livestock are

included in the Farmer Field School. The emphasis is on discovery by the farmers themselves of what may be the appropriate rearing methods. Thus, for example, in the case of ruminants, a key issue emerging has been feed management. The animals should be provided with adequate feed at all times of the year to ensure good nutritional status. This will ensure the fecundity of the Black Bengal Goat and reduce mortality amongst goat kids, as well as maximise the returns from the highly profitable cattle fattening operation. To this end, farmers are 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.

In the same way as with poultry rearing, the FFS learning sessions on ruminants need to be complemented through ensuring the input supply system. Here RFLDC is continuing to experiment with ways to break the existing constraints to further development of all of these enterprises which have considerable potentials in the Noakhali chars. Apart from the feed issue discussed above, these constraints are very similar to those faced in poultry (chicken) rearing: improving breeds, supply of improved feed, veterinary care and marketing. A number of key questions are:

- *Breeds*: How to ensure a reliable supply of improved breeds of Day-old Ducklings when the Government farms, which are the main suppliers, but which cannot offer sufficient supplies and often channel 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 requires feed and husbandry beyond the scope of the poorer farmers?
- *Feeds*: How to identify appropriate feeds and fodders which fit into the existing farm system, which can easily be grown in the various soil conditions of the coastal region and which together can 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 requires 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 has adopted two main strategies to support its development efforts: promotion of adaptive research and encouraging investment by the private sector.

Adaptive research

RFLDC has benefited from special funds available for adaptive research under Danida's Agricultural Sector Programme Support. With these funds, RFLDC has enlisted researchers to carry out adaptive research, especially into the development of feed sources for cattle, goats and indigenous ducks, with special reference to the chars. As adaptive research, these studies are focused on what can be done with the existing resource base of the farmers. Thus the study of cattle fodder focuses on fodders which are tolerant to the partly saline conditions of the chars, while the study on duck feed concentrates on indigenous duck species and the feeds available within the farming system.

Another thrust of research has been on system development, particularly in relation to improving the 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 are being carried out by the Chittagong Veterinary and Animal Sciences University, a close partner of RFLDC. The first study seeks to establish a system whereby disease outbreaks can be more rapidly identified in the community and their spread tracked quickly in order to more rapidly contain the problem. Like most of the other research projects, it has only been underway for around six months and the results are still to emerge.

The second project has already been underway for over one year and is exploring how far it is 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 has confronted the issue of encouraging farmers to be more proactive in animal health care and has had some success in promoting regular de-worming of cattle. The project works through RFLDC's existing network of Community-based Organisations which are responsible through their Community Livestock Worker for organising the de-worming and other campaigns. Under the project, farmers are expected to pay modest fees for the services provided by the private veterinarian.

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

Globally, the most important issue in relation to climate change is probably the reduction of the carbon dioxide, methane and nitrous oxide emissions from intensive livestock rearing systems. Climate change in turn, may affect low input livestock production systems in the tropics through the heat stress on animals, the

expansion of vector populations carrying livestock disease (Avian Influenza outbreaks have been linked to temperature), water shortages and the quantity and quality of available fodders.

Co-operation with private agribusiness

Much of the adaptive research is still to bear fruit, but co-operation with private agribusiness is already having an impact. Based upon the successful collaboration in prawn aquaculture (see Chapter 5), RFLDC has sought to encourage private sector investment in livestock, particularly in the production of improved stock of animals. Already one investor has established a farm for the production of kids of Black Bengal goats and local sheep, which are distributed to poor farmers through the Community-based Organisations. The CBOs pay the market price for their kids, but offer these on the basis of credit-in-kind to the farmers, the recipients repaying a female kid to the CBO when their initial animals give birth. Like the work with the prawn hatchery, the private entrepreneur also offers scope for the project to carry out adaptive research into improved feeding strategies. Thus it has been shown that for part of the year the goats will take a partial diet of urea and molasses treated straw. The adaptive research on goat feeding technology conducted by the Bangladesh Livestock Research Institute is building upon this initiative and is also using 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 has begun to seek partnership with other similar integrated farming enterprises in Noakhali. Some of these are importing their own input supplies, such as molasses, from other parts of Bangladesh, which would otherwise not be easily available in Noakhali. They have expressed willingness to act also as wholesalers to supply the Community-based Organisations. Others have agreed to provide fodder cuttings for local farmers, again to be distributed through the CBOs.

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

RFLDC has not yet addressed all of the problems listed above. It has proved difficult to draw private investment into the production of day-old ducklings. A local government farm in the nearby Upazila of Sonagazi sells ducklings at a substantially subsidised price (Tk. 12 per bird when the real production cost is Tk. 20-22 per bird). This obviously discourages the private sector. RFLDC has been investigating more localised production systems operated by the CBOs. A

problem is, however, that a small incubator system is uneconomic because of the need to establish a back-up generator in the face of uncertain electricity supplies.

Nor has the basic problems of low yield and marketing in the dairy industry been solved, despite the establishment of two milk chiller plants in the region, including one in the Noakhali char area. Although the National Livestock Development Policy calls for maintenance of local improved breeds of cattle (like Red Pabna and Red Chittagong), in practice the emphasise is given to the upgrading of dairy cows through artificial insemination with Holstein-Friesian cross bred cattle. The .offspring of these animals place considerable investment demands on small-scale farmers and arguably they would be better off concentrating on improvements through breeding with the local improved strains. It is difficult for a project to fly in the face of this practice, although RFLDC has introduced Red Chittagong breeding bulls in certain CBOs as a starting point for this alternative.

The subsidy offered by the Government of Bangladesh to importers of powdered milk artificially reduces the price of the finished product and so reduces the price available to producers. Milk Vita, the owner of chillers, calculates the price based upon fat content, which has a further negative impact on income of farmers, who are unable to maintain the desired quality.

6.5 CONCLUSIONS

6.5.1 Potential for Livestock Development

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

6.5.2 Constraints in Char Areas

However, this potential is constrained by isolation which denies farmers access to the appropriate information to improve their system and also to 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 remains underdeveloped and the services provided by the Government just do not reach to such isolated areas.

6.5.3 Ongoing Interventions

RFLDC is now attempting to address some of the key problems through simple technical improvements in rearing systems under the Farmer Field School, now supported by adaptive research, as well as the provision of services through Community-based Organisations, with strong links to the private sector. It is the hope that this system will help farmers to become more self-reliant and make extension services more sustainable.

6.5.4 Role for the Private Sector through Policy Change

However, this is work ongoing and it 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.

6.5.5 Impact of Climate Change

Sidr and Alia have recently shown what devastating effects cyclones can have on the livestock population, particularly but not only poultry birds. The general expectation is that cyclones will occur more frequently due to changes in climate. Low input livestock production systems as applied in the chars can hardly be blamed for contributing to global warming due to carbon dioxide, methane and nitrous oxide emissions. But such systems can be affected by climate change through the heat stress on animals and the higher frequency of outbreaks of livestock diseases. 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.

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

7.2 AVAILABILITY OF WATER FOR AGRICULTURE

7.2.1 Surface Water Resources

As we will see in Section 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 rain water 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 2500 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 and have been 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).

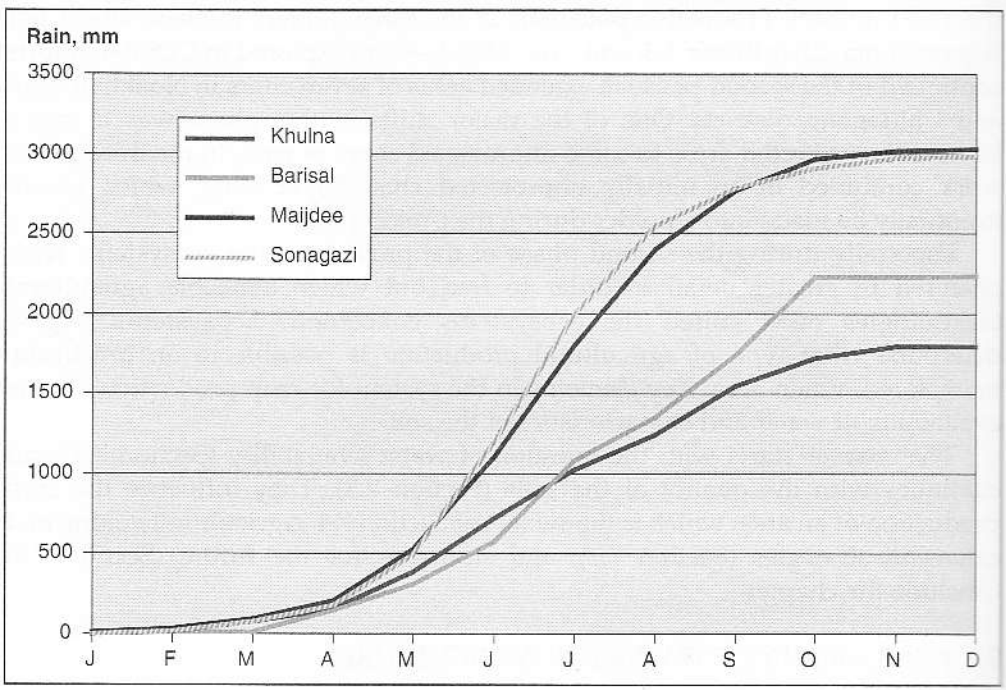


Figure 7.1: Cumulative rainfall at four locations in the coastal region

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

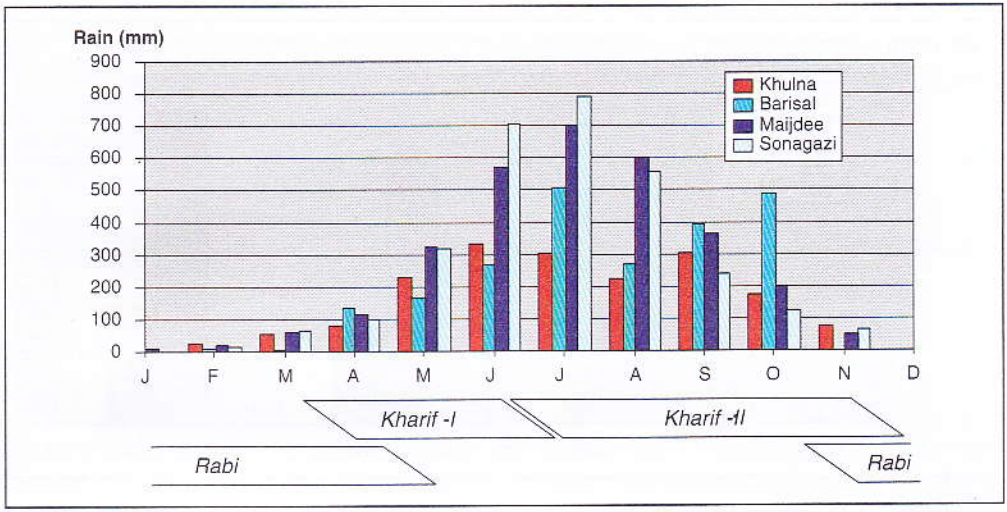


Figure 7.2: Monthly total rainfall at four locations in the coastal region and its relation with the cropping seasons

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 the *rabi* crops demand irrigation water.

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).

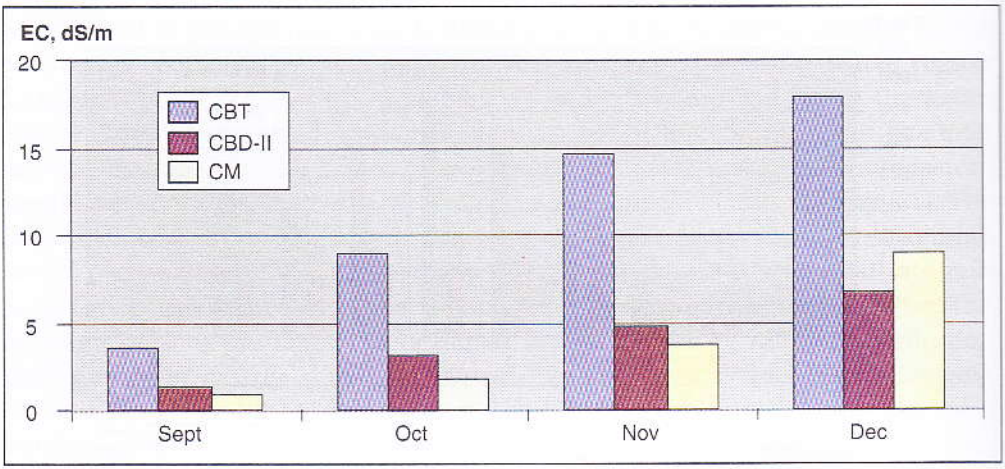


Figure 7.3: Maximum salinity of canal water outside sluices (sea side) of three polders of CDSP: Char Bhatir Tek, Char Baggar Dona–II and Char Majid

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.

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.

(a) 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 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 their levees much higher to impound more water (up to 50 cm or more).

Table 7.1: Monsoon flooding depth at various project locations reported by farmers

Location	Peak monsoon flooding depth (cm)	
	Minimum	Maximum
Mora Dona	12	90
Char Lakshmi	12	122
Gangchil-Torabali	15	183
South Hatiya	15	107
Bandartila	15	167
Nijhum Dwip	15	122

(b) 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, localised 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 centre 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.

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 Grater Noakhali area. The recharge characteristics of the aquifers and the risk of salinisation 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 of Soils and Fertility

The Noakhali coastal region is part of the Young Meghna Estuarine Floodplain, and 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 characterised 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.

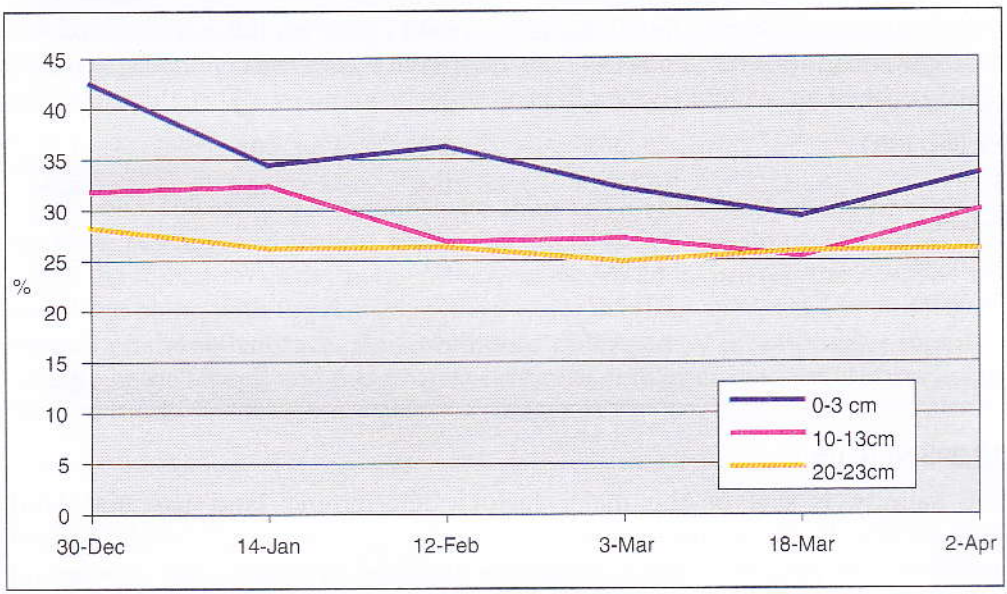


Figure 7.4: Soil moisture (%) in three layers after the harvest of aman rice at Char Majid and Mora Dona (mean of six fields)

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 (p^H ranges from 7.0 to 8.8) while sub-soils are mostly alkaline (p^H = 7.5 to 8.8). Induced nutritional imbalances often occur in such soils, particularly of zinc and phosphorus.

Analysis of soil samples from the areas of CDSP-II 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 the CDSP areas

Nutrients	Range	Mean	Critical	Optimum
Total N (%)	0.04-0.11	0.06	0.12	0.27
Avail. P (ppm)	0.16-11.09	4.63	10.0	22.5
Exch. K (me/100g)	0.29-1.83	0.61	0.12	0.27
Ca (me/100g)	7.4-14..06	10.2	2.0	4.51
Mg (me/100g)	7.5-13.71	10.0	0.5	1.13
S (ppm)	110.7-309.4	215.0	10.0	22.5
Fe (ppm)	17.2-93.0	46.4	4.0	9.1
Mn (ppm)	2.7-69.9	50.1	1.0	2.26
Zn (ppm)	0.11-5.87	1.10	0.6	1.35
Cu (ppm)	2.37-5.39	3.94	0.2	0.45
B (ppm)	0.99-1.10	1.06	0.1	0.45

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 (see 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.

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 desalinisation 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.

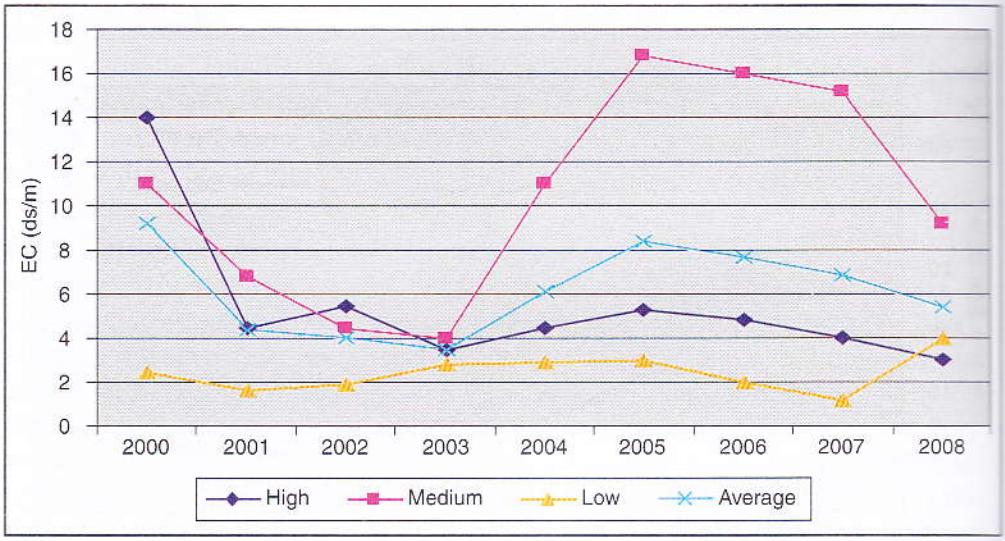


Figure 7.6: Soil salinity in March/April in Char Majid

Figure 7.6 shows the development of soil salinity in Char Majid (protected in 1998) at three different location in the polder with high, medium and low levels, based on data when the measurements started. Also the average value is depicted. Samples were taken at these three different locations at two different depths (0-10 cm and 10-30 cm). Over the years, the average shows a downward trend, with an increase in the 2003-2005 period. 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 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 characterised 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 (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 Sections 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 *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
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 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%. For Boyer Char (CDSP–III), the intensity was 131% when the project activities started (2005) and increased to 185% in 2009.

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 programme 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 fertiliser, were obstacles in this adoption process.

The, rather erratic, changes over the years in use of HYV are shown in Figure 7.7 and 7.8 for three CDSP–I areas (all protected by the project) for the *aus* and *aman* seasons respectively. For *aus* rice the increase was practically from zero to about 20 and for *aman*, the increase in HYV adoption was as high as 27 to 33%.

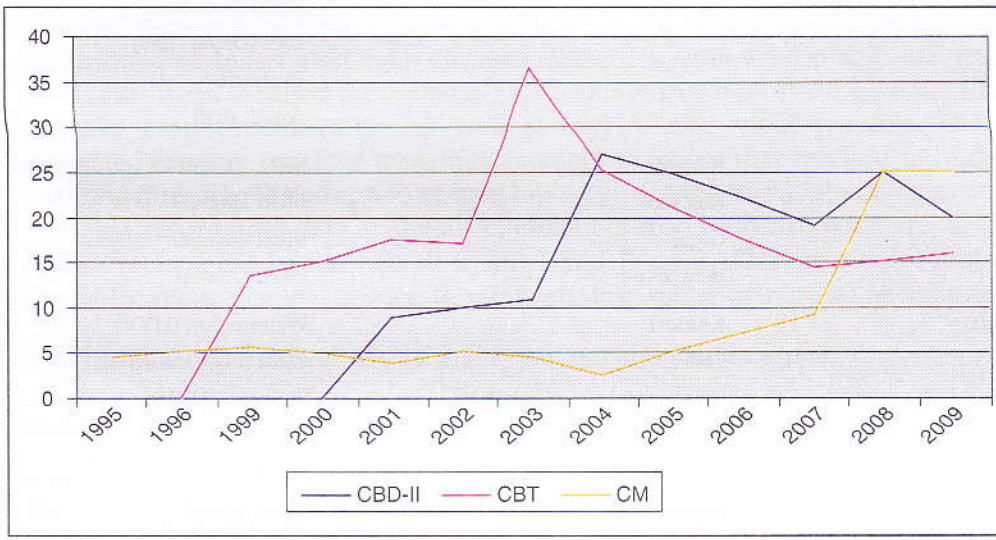


Figure 7.7: HYV aus rice adoption in CDSP–I areas, 1995-2009

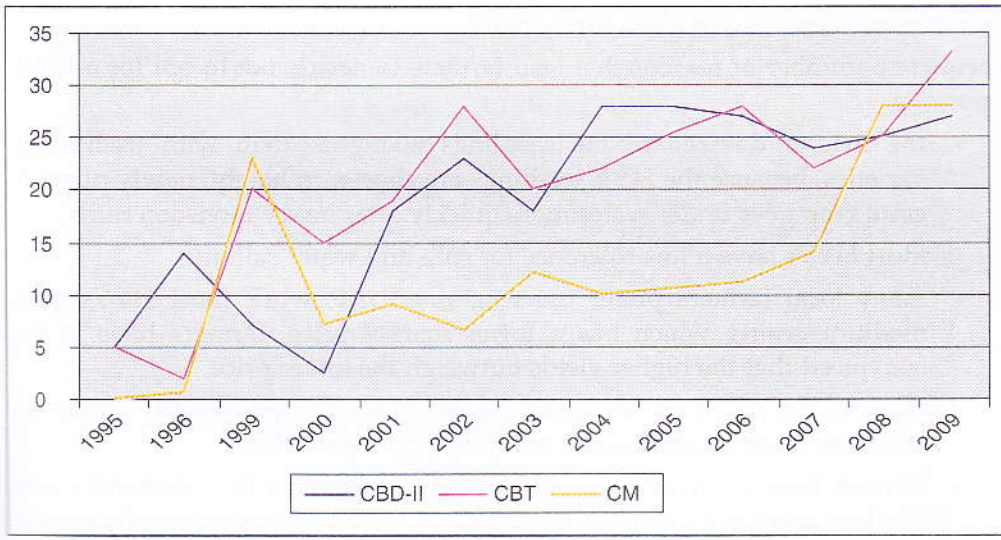


Figure 7.8: HYV aman rice adoption in CDSP–I areas, 1995-2009

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.

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)

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 fertiliser and more intensive weed control; local varieties are mostly grown without fertiliser

- 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.

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

Table7.5: Mean yield of crops (kg/ha) during pre- and post-project periods

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

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.

Choice of crops

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

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

Table 7.6: Tentative tolerance of field crops to top soil salinity, measured during the *Rabi* season

range of EC_e				
April value	< 8	8 - 16	16 - 30	> 30
	sunflower	aus	chili	no aus, no *rabi*
	soybean	groundnut	sweet potato	
	wheat	linseed	green gram	
	cowpea	garlic	batisak	
	mung bean			
	okra			
	water melon			

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 favourable 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 a more costs and labour are; 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.

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 minimise 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.

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. DAE staff were not familiar with participative extension approaches and training efforts to fill this gap were not adequate. 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

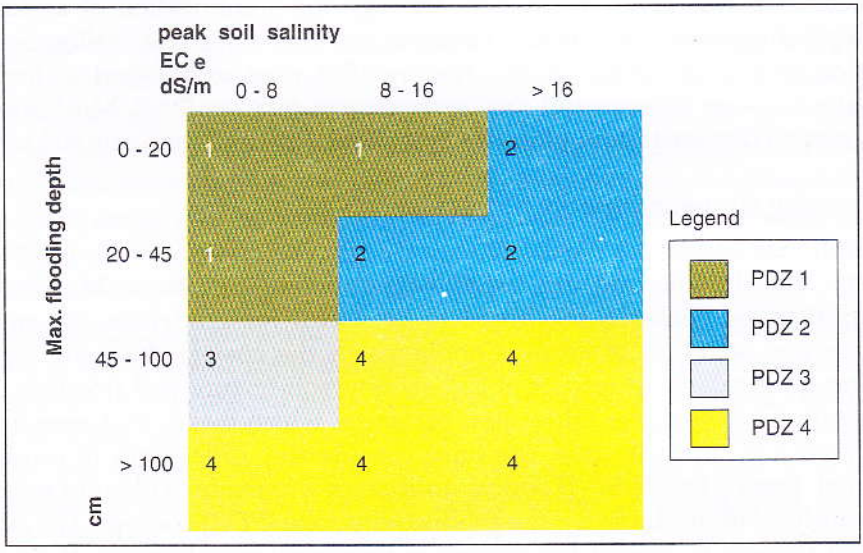
As mentioned earlier, the Noakhali coastal region belongs to the Young Meghna Estuary Floodplain, and represents Agro Ecological Zone 18. The AEZ classification is, however, too broad to be useful for guidelines for cropping patterns and selection of crops. Conditions in the coastal chars are far from uniform, particularly in respect of soil salinity, soil texture and flooding depth. Variations exist even 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 characterising 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 EC_e 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:



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.

Prod. Zone (PDZ)	Characteristics
PDZ 1	**"Shallow flooding, low to medium salinity". Favourable 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.

(contd.)

(contd.)

Prod. Zone (PDZ)	Characteristics
	• 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". Favourable *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 (*Sarjan*) can be tried with crops like summer and winter vegetables.
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 (Figures 7.9 and 7.10). To demonstrate the difference between the chars, the table in between the maps (Table 7.7) gives the area in each char under each of the four PDZs.

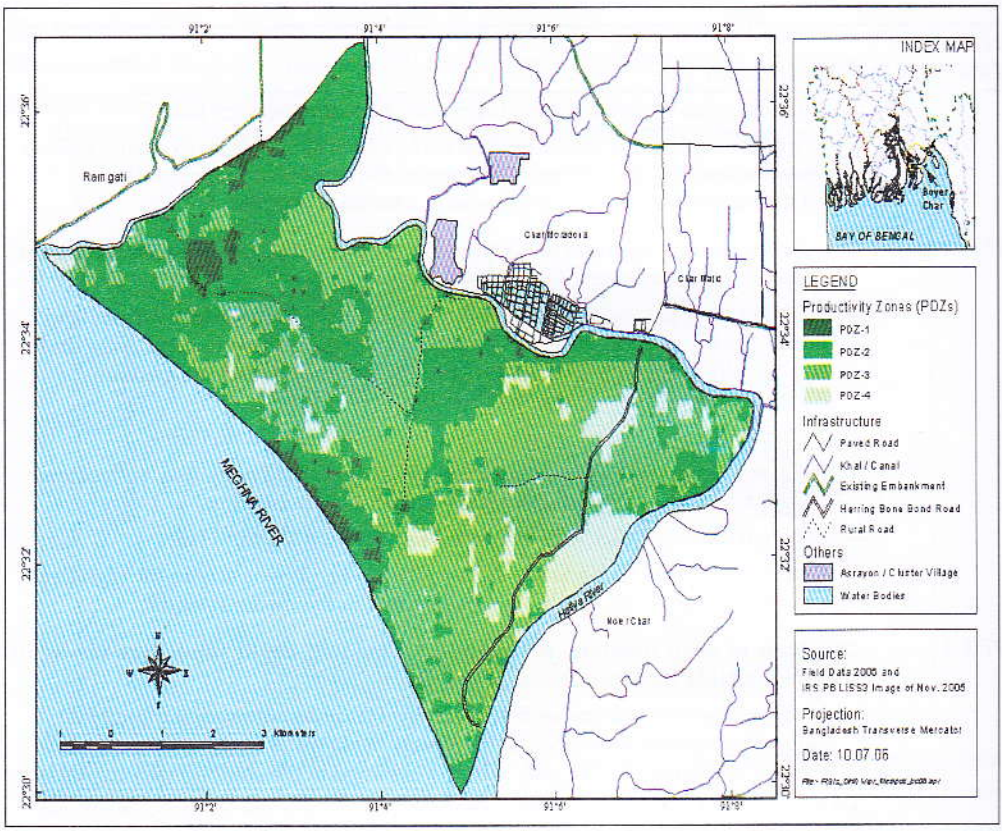


Figure 7.9: Productivity zones of Boyer Char

Table 7.7: 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)

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.

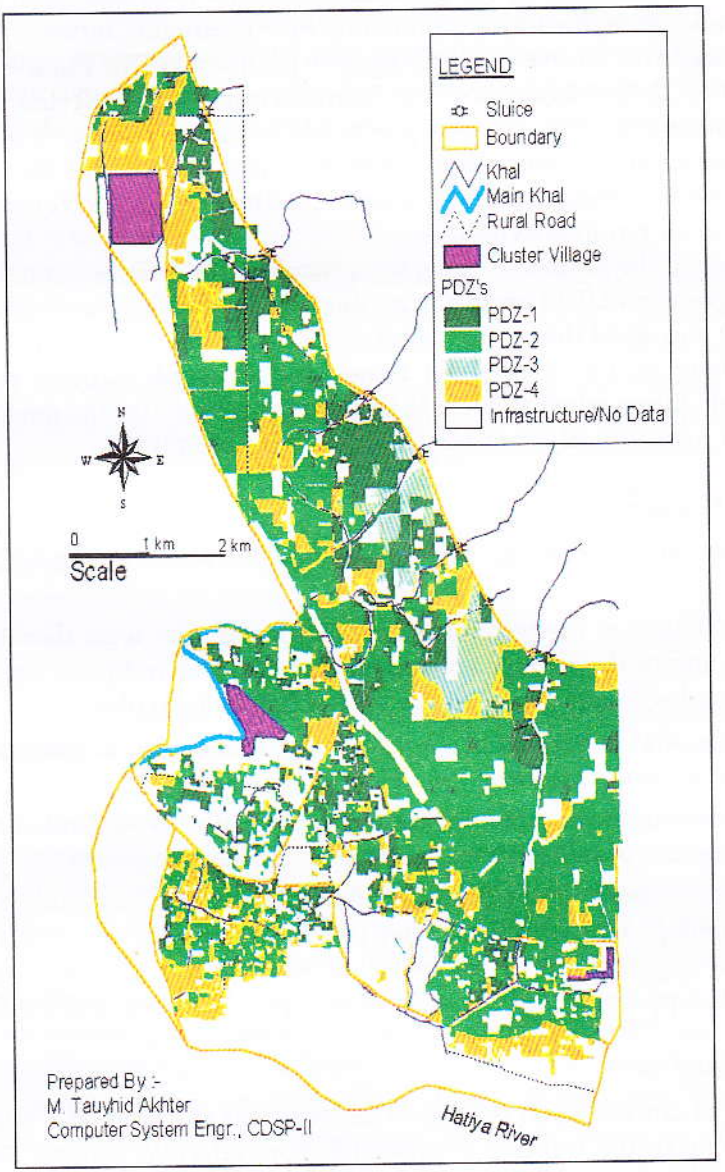


Figure 7.10: Productivity zones of Mora Dona

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 homogeneous 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 m^2, 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 labour and, if possible, other required inputs. However, depending on the type of technology, DAE supports the farmer with some inputs like seed and fertiliser.

Farmer training

The system of conventional classroom lectures was changed to a participatory dialogue to make the training programme more effective. Farmer Forums are taking the organisation 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 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 labour. 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 organised, 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 neighbouring 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 are seldom benefited from these 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

7.6.1 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.

7.6.2 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 socoi-economic benefits and the size of the required investments should be looked at.

7.6.3 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 *khals* 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.

7.6.4 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.

7.6.5 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.

7.6.6 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 organisations 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 organisations, while field work could be implemented jointly, mostly through engaging temporary researchers on a result-oriented contract basis.

7.6.7 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.

7.6.8 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.

7.6.9 Livelihoods

The maximum ceiling of allotments of lands to landless households in newly accreted *khas* land areas stands a 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 programme 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

8.1 INTRODUCTION

In a country as densely populated as Bangladesh, with between 900 and 1,000 people per square kilometre, 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 favouring 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 (land owners) 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 60 *bighas* (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 dependant 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, 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 loose 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. 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 and thereby, 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

(a) 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 12,30,000 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 stabilisation of the accreted land in order to make the land suitable for cultivation. An area of 4,50,000 acres of land was located in Noakhali District, falling between 22° 30′ to 21° 30′ North Latitude, 91° 00′ to 91° 30′ East Longitude. In the Notification it was clearly mentioned that these lands would be returned to the Ministry of Land after the tenure of 10 years. However, the area has 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 stabilisation. 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.

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 under the World Bank and other programmes. But people who lost their land in neighbouring 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) 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 decision was 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 of 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 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. So, the status of these lands remains *khas* land an 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. The eviction by force of settlers from their land was one of the 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 Section 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 honour 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 favour 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 land. This department cannot do its work 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 can 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 *mouzas* (a unit of land administration which is drawn on revenue maps during the revenue/cadastral survey by DGLRS; *mouzas* are formed, maintained and used by the land administration) is changed every year. 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 can not supply the exact data on areas of the *mouzas*. 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 harmonisation is called for. The Zonal Settlement Officer, the official representative of DGLRS, can play a fruitful role in this respect.

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 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 common.

The illegal immigrants and occupiers of 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 *jotdars*. 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 *jotdars* 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 of land settlement. The precise rules of settlement are stipulated in the State Acquisition and Tenancy Act of 1987. The two combined lead to the following procedure for the whole process, from identification of *khas* lands to the distribution of land titles.

A. Selection of Khas lands for settlement

(i) The Upazila (sub-District) Agricultural *Khas* Land Management and Settlement Committee, having 13 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

(ii) Objections to this preliminary list have to be submitted within 30 days and the Upazila Committee gives its decision within 15 days, and then publishes the final list.

(iii) 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 the Parliament acts as its Advisor. This District Committee gives its decision within 15 days,

(iv) 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.

B. Selection of landless households for settlement of khas lands

(i) Applications from landless people are invited by the AC (Land) of the Upazila to be submitted within one month.

(ii) Within one month the Upazila Committee finalises the scrutiny of the applications and prepares the list of selected candidates for settlement of *khas* land.

(iii) 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.

(iv) 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.

(v) Within 30 days, the Deputy Commissioner refers the cases to the District Committee and the District Committee scrutinises and approves the Upazila list.

(vi) 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.

(vii) *"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.

(viii) Executed *Kabuliyats* are approved and signed by the AC (Land)

(ix) *Kabuliyats* are then registered by the Upazila Sub-Registrar.

(x) *Khatians* (records of right) are prepared by the AC (Land) within 15 days.

(xi) *Jodhs* (records of mutational *khatian*) are opened within 21 days.

(xii) Finally, the *khatian* is handed over to the landless family and possession of the land to the settlement holders, 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 summarised 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 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.
h. *Khatians* (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. Based on that 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 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.

After the establishment of more permanent institutions as Water Management Organisations, 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 Organisations (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 extent of the land, its title status and its 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 and the 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 finalisation 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 finalising 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 solved 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 the project, the secretary Ministry of Land gave a local declaration in May, 2007 for writing the women's name at the first place in the *khatians* 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 decision will further stimulate the empowerment of women settlers, strengthen the conjugal ties and ensure retention of their land. This practice may be replicated by the Government in other areas also.

Singing and registration of kabuliyat and handing over of khatian are done in the field

Registration of the documents is generally done at the Registration offices, which are usually located at the Upazila headquarters. If anybody wants to have the documents registered at any other place, for instance 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 fee. In case of CDSP, the Ministry of Law on the recommendation of the Ministry of Land, instructed the Sub-Registrar of Hatiya Upazila to hold 'field registration camps' at Boyer Char for registration of the *kabuliyats* at least once a month. It is the first time in the country such field camps are held. This has saved the people of Boyer Char from going up to the distantly located Hatiya Upazila head quarters to appear for the Sub Registrar. And they did not have to pay the extra fee of Tk. 450.

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 15,876 land titles have been issued in a period of about 13 years (mid 1997 to mid-2010) 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

Project phases	*Khatian* distribution (households)	Land Settlement (area in acre)	Remarks
CDSP-I	4494	5524	Period 1994 to June 2010
CDSP-II	7837	11725	Period June 2000 to June 2010
CDSP-III	3545	3900 (approx.)	Period Oct. 2005 to June 2010
			Target 9,500 hh.; approx. 10,500 acres
Total	15876	21149	

8.4.2 Land Retention

The previous table shows that, to date, nearly 16,000 households received a title on land in the context of one of the phases of CDSP. In all, the land involved was around 21,000 acre, which means that the average size of allotted land to 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, CDSP started in the year 2000 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.

Analysing the samples, it turned out that 6.1% of the households that received a *khatian* were not living inside the area concerned (see Table 8.2). 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 8.3).

Table 8.2:: 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

Note: CM=Char Majid CBD–II=Char Baggar Dona–II CBT=Char Bhatir Tek MD=Char Mora Dona

Table 8.3: 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, the settlers did not get possession of all their allotted land because they were denied the possession by the previous occupiers, in most cases *jotdars* 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 8.4: 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. Sine 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 8.5 provides details per area.

Table 8.5 shows the land loss of the local official settlers who have left the settlement locality. Table 8.6 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

Table 8.5: Distribution of local settlers by present location status

Settler Types	Polders									
	CM		CBD-II		CBT		MD		Total	
	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

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 *jotdars* 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. It should be noted, that official settlement in the CDSP–I areas started nearly 15 years ago.

Table 8.6: Land retention status of the settlers still living in the locality

Areas	No. of HH	Average land (acres) and lost/sold			% of land retention	
		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 8.7. 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 *jotdars* and their *bahinis*.

Table 8.7: Present land holding status of the settlers still living in the locality

	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 *jotdars* 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 8.8.

Table 8.8: *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. A number of them occupy *khas* land in newer, still not officially settled chars. This is against the law as well. These facts should be taken into account in any new settlement operation in the chars, such as is foreseen under the fourth phase of CDSP. A proper land management information system would greatly facilitate any actions against illegal activities.

8.5 MODERNISATION 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 modernisation 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 modernise the

land record management system. This system has been applied and tested for management of the *khas* land settled under CDSP-II and III areas.

The system is suitable for keeping records of all the Government, non-government and private lands, records of mutation, issuing and updating the *khatians* (records of right) and maintenance and updating of the registers and records of the settled and mutationed lands used in the Upazila - and Union level land offices.

Based on the result of the CDSP, Govt. of Bangladesh has been initiated a pilot activity to bring two Upazilas (Sub-Districts) namely Companiganj Upazila of Noakhali District and Ramgati of Lakhsmipur District, into this computerised system. This activity has been 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 has been looking forward to develop a system of E-Governance in the Ministry, the attached Departments and the Land offices of District and Upazilas under a project with the followings objectives: (a) to develop a customised application of software for imaging, archiving, retrieving and printing of *khatian* and *mouza* maps; (b) to use the customised software, computerisation of all CS, SA and RS *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 Ministry of Land has as yet not been able to attract any donor funds and has now proposed that the Government of Bangladesh funds the project. This is a huge and ambitious programme and it is not likely to be implemented within the foreseeable future without considerable technical support from donors. However, CDSP will continue with its LRMS programme with some improvements in its next phase.

8.6 SUGGESTIONS FOR FUTURE SETTLEMENT OPERATIONS

8.6.1 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 affairs. This situation gives rise to serious considerations for re-inforcement of the capacity of these land offices in coastal areas. A special working strength for coastal Districts and Upazilas have to be introduced by the Government so that these offices may keep an effective control over areas with substantial accretion. Relocation from other offices is an obvious solution that would not require any increase in the personnel budget.

8.6.2 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.

8.6.3 Changes in the Land Settlement Procedures

The Ministry of Land should consider to introduce the CDSP methodology in respect of the land settlement activities in all land settlement programmes 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.

8.6.4 Coordination in Preparation of Maps

Improved coordination and harmonisation 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.

8.6.5 Application of Procedures in Future Programmes

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 jotdars. Such developments can be corrected by a strict application of selection rules in the new chars in the fourth phase 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.

8.6.6 Mechanism to Solve Boundary Problems Must be Developed

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.

8.6.7 Modernisation of Land Records Management System

Bangladesh should rapidly move towards a computerised 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 software developed under CDSP and the results of the ongoing pilot activity in two Upazilas would be a good starting point in the process of designing a country-wide programme.

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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 programmes 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 programmes.

9.2 THE HETEROGENEOUS CHARACTER OF THE EARLY GROUP OF 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 practically all settlers are erosion victims, while for the older chars as Char Majid 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 move because they are victims of coercion and threats in their area. Some families are accompanying their neighbours who decided to migrate. Others are 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 move to chars, come from far away and near by places, but all migrate within the greater Noakhali area. For example; the settlers to the Boyer Char of Noakhali came from Hatiya, Ramgoti, Sandwip, Shajbajpur, and Noakhali mainland. In Urir Char they have migrated from Sandwip, Noakhali main land and Hatiya. Percentages of settler 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 drawn by professionals based on the available data and practical experience. The high percentage of migrants 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 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
Swandip	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).

Table 9.2. Periods of migration

Name of Area	% of migration in different period			
	70-79	80-89	90-95	95-2000
Moradona	6.45	25.00	30.65	37.90
Boyer Char	0.00	0.00	26.00	74.00
Upstream	96.04	1.98	1.98	0.00

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 localities.

This pattern favours 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.

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 characterised 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 the 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.

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 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 Boyer Char, 16 of such schools have been established.

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 institutionalisation 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 organisations. 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 summarises all the field level institutions formed under the three phases of CDSP.

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 is 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

Table 9.3. Summary of the field level institutions in CDSP-I, II, III areas

Type of field level institution	CDSP-I	CDSP-II	CDSP-III	Total
Water Management Organisation (WMO)	WMG(3)	WMG(40) WMA(7) WMF(2)	WMG(10) WMA(1)	WMG(53) WMA(8) WMF(2)
Sub Polder Committee (SPC)	15	–	–	15
Polder Committee (PC)	3	1	1	5
Local Area Development Committee (LADC)	–	5	–	5
Farmers Forum (FF)	3	35	35	73
Social Forestry Group (SFG)	–	–	114	114
Labour Contracting Societies (LCS)	6	–	15	18
CBO/Farmers Field School (FFS): RFLDC-Danida NGO Group	–	657	341	998
Tube well Users Group (TUG)	229	320	600	1149

Note: WMG = Water Management Group; WMA = Water Management Association; WMF = Water Management Federation

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.

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 for limited infrastructure planning. One LADC was formed 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.

9.4.4 Water Management Organisation (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. 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. 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. The WMGs are engaged in two types of interdependent activities: water management activities and organisational activities. Average membership of a WMG is 37, with 53% male and 47% female (in 2010).

The major activities are as follows: preparation of an annual plan for maintenance of water management infrastructures; operation and maintenance of sluices; maintenance drainage *khals*, outfall channels of sluices, embankments, road, bridge/culvert, etc; collection of shares and savings; fund generation through subscription and local resource mobilisation, 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; providing information to local people on useful topics through posters, leaflets and 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, 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)

The objective of organising Farmer Forums is to enable farmers to make better use of their land in order to increase their crop production. Organising farmers groups for extension purposes is in line with the policy of the Department of Agricultural Extension (DAE). This department 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 comprises 25 to 30 farmers (women 20%), 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 July 2010 as an umbrella organisation of the Farmer Forums and as a platform with a connection to the WMGs. The Association consists of 20 male and five female members, both from Farmer Forums and WMGs.

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; ensure the use and management of equipment and inputs supplied by DAE; maintain linkages with DAE, other agencies, NGOs and other field level organisations.

9.4.6 Social Forestry Group (SFG)

Social Forestry Groups have been organised 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 (recently amended). SFGs have been organised 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. 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 and coconut palms. Main activities were road- and embankment 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), FD 10%, Union Parishad 5%, while 10% will be kept for re-plantation in a "tree-farming fund".

9.4.7 Tube Well Users Group (TUG)

A TUG has one female member from each users household around a tube well. A total of 1,149 TUGs, each with about 15 members, have been formed by NGOs (with support from DPHE) in CDSP-I, II and III areas. 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.

9.4.8 Community Based Organisation (CBO)

In the RFLDC project, CBOs are the key institutions for development of sustainable fisheries and livestock extension for resource poor farmers. 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; organising group marketing for agro products; extension services through Farmers Field Schools.

9.4.9 NGO Group

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 are engaged: Sagorika, DUS, Hashi, Upoma and NARS. They implement similar programmes, each in about one fifth of the area. The five NGOs have formed 341 female groups, 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 has 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 organised 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 organise short training sessions for the forum members on relevant issues.

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 *bahinis*, 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 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 programmes, 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. 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. WMOs can also raise their issues at those meetings through the concerned UP/Upazila Chairmen or staff of BWDB, LGED or Department of Cooperatives, 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 programmes. LGIs could lease out drainage *khals* 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. In practice it is seen that some WMO members are also UP members and are consequently well placed to develop such a linkage.

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 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 National Steering Committee (NSC), chaired by the Secretary of the Ministry of Water Resources, with representatives from parent ministries of the implementing agencies, Planning Commission, IMED and BRAC (because of its role as coordinator of the NGO programme). A representative of the donor agency (in this case the Netherlands embassy) 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 Director of the lead agency (BWDB), while the Project Directors of the other five participating agencies and BRAC, as coordinator of the NGOs, are member. 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 marginalised remote areas, with six Government agencies and local 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

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. Establishing a platform where coordination can take place and ways of cooperation can be identified, is something worth considering for future char development programmes. The chances for duplications and misunderstandings would be further reduced. One should be aware however of "bureaucratisation" 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.). The Farmers Association as formed in July 2010, brings 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 total of 11 UP members are member of a 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 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 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 programme 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 programme 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 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 and Farmers Forums 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 a maximum of 200 after about 10 years (intensity of 100 equals 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 close to 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. 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 Boyer Char products. On the other hand, 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 fuelled 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. All these developments have created employment opportunities for people in Boyer Char. 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 *khals* 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 78 m by 78 m), 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 labour, 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 and Chittagong to make additional money as day labourer.

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. 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.

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, all cyclone shelters have been designed with the school function in mind: they have built-in black boards, the design includes teachers rooms, while the tender for the building includes school furniture. 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.

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 centre. In the NGO-programmes, social services have featured more prominently. Health and family planning, human rights and water and sanitation were sub-components of the work of the local NGOs.

9.7.2 Impact on Vulnerable Position of Settlers

The combined impact of these changes can probably best be summarised 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 organisations that also served as vehicles for conflict resolution, the presence of the Government administration, 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 community based organisations), 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 Organisations, and to a lesser extent the Social Forestry Groups, 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 organisations 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 have learned what their rights are 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 sixteen years after the first phase started and ten years after it was completed, we can conclude 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. Urbanisation 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, 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 characterised 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 probably greater than in the average area elsewhere. The inhabitants have organised themselves into community based organisations 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 characterised 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 on the coastal chars. Women often lack choice, voice and skills, which is inextricably related to their vulnerable economic position and further contributes to their marginalisation and exclusion. As a result, women often find themselves in an extremely disadvantaged position and are characterised 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 characterised 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 sphere. 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 characterised 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 organisation 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 by June 2009. 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 formed under CDSP-III 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.

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-III however, is the first and up until now 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 the position and status of the female population on the coastal chars.

Awareness raising activities have often been aimed at sensitising 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 nurturers 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.

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. 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, but 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. 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, in certain areas, like Boyer Char. Important in this regard have also been gender awareness raising programmes and CDSP-III's policy of depriving perpetrators of severe violence against women of their share of land. 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 PROGRAMMES

9.8.1 Participative Land Management System in Period of Afforestation

As was seen in other chapters as well, the autonomous migration into new chars guided by *bahinis* 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.

9.8.2 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.

9.8.3 Local Government Institutions

Future programmes 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 their respective *parishads* should in particular be strengthened.

9.8.4 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 formalised to a higher degree in future development activities. A pro-active role of the District administration would facilitate this process. The CDSP-model for coordination among state agencies and between state agencies and NGOs has been successful and can serve as a best practice model for future programmes.

9.8.5 Improved Livelihoods and Self-confidence

Economic growth and access to social services have contributed to the self-confidence of settlers 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 programme 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

There is now an increasing consensus among academics and development practitioners alike about the reality of climate change and associated disasters, and their manifold implications for the lives and livelihoods of the communities living along the coast. Of late, there have been attempts to document and research the resilience of communities and their coping mechanisms. In this context, this chapter offers an overview of community based adaptation (CBA) to climate change impacts, primarily by drawing on some empirical experiences from the southern coastlines of Bangladesh.

The discussion is organised under six sections. Following this general introduction, the next section describes the perils of climate change and its effects on the coastal zone of Bangladesh. The third section illustrates the significance of community based adaptation to climate change in Bangladesh, since the coastal area is one of the most vulnerable areas of the country. Involvement of local communities in the adaptation programmes and projects is crucial, as they are the key stakeholders and/or beneficiaries. After this, the fourth section talks about vulnerability and highlights one of the methods that are used in the assessment of vulnerability, namely Participatory Vulnerability Assessment (PVA). Section five essentially describes the role of local government agencies in facilitating adaptation. In Noakhali, the Department of Agricultural Extension (DAE) plays a pivotal role in promoting alternative cropping techniques, thereby facilitating adaptation to specific effects of climate change such as salinity intrusion. A number of best practices of CBA in Noakhali have been compiled in section six. The CBA examples range from awareness related initiatives to adaptive research on disaster resilient structures such as houses and boats. The epilogue in section seven gives a number of clues for future research and further thinking.

10.2 THE COASTAL ZONE AT RISK

The impact assessments of the Intergovernmental Panel on Climate Change identify Bangladesh as one of the most 'susceptible countries' of the world to the negative impacts of climate change. The intensity and magnitude of these hazards vary over space and time. The pattern and behaviour of climate and weather play a significant role in freshwater availability, agriculture and economic performance in general and therefore have a serious impact on livelihoods of households in coastal areas. 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 clear that adaptation strategies are pivotal in identifying and formulating Bangladesh's future development programmes.

With vulnerability we mean the characteristics of a person or group and their situation, that both influence their capacity to anticipate, cope with, resist and recover from the impact of a disaster. It involves a combination of factors that determine the degree to which someone's life, livelihood, property and other assets are put at risk by a discrete and identifiable event (or series of such events) in nature and society.

In the coastal zone of Bangladesh, a wide range of vulnerabilities have been identified:

- the threat of cyclones and storm surges
- the threat of land erosion and dislocation
- deterioration and declining viability of distinctive and threatened coastal ecosystems
- widespread poverty, limited livelihood opportunities and poorly developed economic linkages
- a poor level of service provision
- highly unequal social structures, linked to a high level of conflict and to a poor law and order situation
- changing patterns of land use, including the growth of shrimp and salt production
- degradation of natural resources
- poor access to many forms of infrastructure and technologies
- surface and sub-surface salinisation, including saline intrusion into the freshwater aquifers and
- flooding and drainage congestion problems

These vulnerabilities affect the livelihoods of coastal communities. Their significance, however, vary greatly between localities, occupational groups and sexes. Also important is the way in which vulnerabilities interact with each other. Most coastal households, and especially the poor ones, 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 example, the poor infrastructure and remoteness of many coastal localities mean that the immediate impact of a major cyclone is likely to be more severe and relief efforts are hampered. Subsequently, when the 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, delay and hamper the recovery process. These vulnerabilities affect different households differently. In general, the more affluent a household is, and in particular the more assets it possesses, the more resilient it is to disruption of its livelihood base. The overall social environment makes women and children more vulnerable.

Various approaches to analysing vulnerability exist, both quantitative and qualitative. Certain vulnerabilities for some groups of people may be reduced, either through people's own actions (reaching a cyclone shelter in time), or through the actions of governmental and local authorities (keeping storm drains clear), or through the interventions of aid agencies (building cyclone shelters).

People can use the process of vulnerability analysis to reflect on what they want to do about their situation. A result of the process can be the design of development programmes to increase resilience, building on the identified strengths of people. Reductions in vulnerability may be used as indicators of development progress, keeping in mind that vulnerability varies widely across communities, sectors and regions.

10.3 COMMUNITY BASED ADAPTATION (CBA)

Climate change is a global phenomenon with diverse regional effects. Adaptations, in general, are strategies aimed at counteracting regional and area based climatic changes. Specific local situations have to be taken into account to develop effective adaptive measures, along with local communities.

Per definition community based adaptation (CBA) is the identification and institutionalisation of mechanisms that allow the most vulnerable local communities to cope with climate change. Decentralised programmes have to be used for the promotion of local adaptation within the framework of coherent national policies. CBA is a bottom up approach by which a community is positioned as the main entity to implement adaptations and is considered to be the subject of projects for competence and technology development to increase adaptive capacity.

The adaptive capacity is the resilience of the system to unpredictable shocks. Adaptation strategies should include local actions taken by the poor themselves in response to changing market or environmental conditions supported by larger-scale, planned responses by government or other institutions that provide adaptation measures that are beyond the control or capabilities of local communities.

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. They have to interact with administrative entities and share their traditional knowledge for the effective development of solutions to cope with the changing climate. 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, integrating adaptation measures and addressing cross-cutting issues such as Integrated Costal Zone Management (ICZM). It is of utmost importance to involve local communities in the accumulation and dissemination of activities on climate change and 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 recognising 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.

Table 10.1: Core principles and the steps in conducting Participatory Vulnerability Assessment (PVA)

- Active agency, in which poor people can and must be involved in finding the solutions to the problems they face.
- PVA is not an end in itself; it should result in action and change for the better.
- The sources of vulnerability and solutions to vulnerability are located or controlled outside the community, so one needs a multi-level process.
- PVA is based on rights based principles.
- PVA uses a step-by-step approach to systematically analyse the causes of vulnerability by:
- Tracking hazards to determine the level of exposure to risk, causes and effects.
- Examining unsafe conditions (factors that make people susceptible to risk at a specific point in time).
- Tracking systems and factors (dynamic pressures) that determine vulnerability, resilience and root causes.
- Analysing capacities and their impact on reducing vulnerability.

Source: Action Aid International

The approach brings the sum of all parts neatly together, i.e. listening to people, hearing people's voices, measuring how effective strategies are in reducing vulnerability and generating people-centered advocacy.

10.4 CBA IN PRACTICE IN NOAKHALI

In this section, we share some examples of CBA based on the experiences of IUCN B, over the last decade. Needless to mention, the cases discussed below are certainly not exhaustive and focus only on the coastal district of Noakhali. The purpose is to provide the readers with an impression of the diverse range of initiatives that are practised in one of the most vulnerable coastal areas of the country. Much of this experience was derived from activities on promotion of adaptation to climate change, funded by the Netherlands Climate Assistance Programme. The major objectives were to examine climate changes on fisheries and agriculture, generate discussion on climate change and adaptation and recommend possible adaptation measures. The PVA methodology as elaborated upon in the previous paragraph was adopted by IUCN Bangladesh, in the assessment of risks and vulnerabilities of the coastal areas of Noakhali.

10.4.1 Perception of Communities Regarding Climate Change and Its Consequences

Analysis of the data of the study area shows signs of increasing temperature and climatic variability. Seven out of the 10 hottest years on record have occurred since 1990. Also the wettest and driest monsoon seasons are on record in recent times, indicating an erratic pattern of extreme weather which has serious consequences for agricultural practices. There is an increase in the frequency of the lowest category of depressions as well. Especially, 2007 was a year marked with rough seas throughout the year, it drastically reduced the number of working days for seagoing fishermen.

The perceptions of the local people and the observed changes in climate are similar. The perceived changes in climate reported by the people were:

- 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

The following table summarises the findings of the PVA carried out in one of the 21 unions of Noakhali District, based on people's perceptions of disasters and risks.

Table 10.2: Probability of risk and ranking matrix of Binodpur Union, Noakhali

Type of Hazard	Reported Events/ Incidents 1997-2007	Probability of Occurrence	Significant Number of People Affected	Primary Costs (economic)	Secondary Costs (response)	Level of Vulnerability
Water logging	1	1	1	1	0.1	1
Salinity	0.001	0.001	0.01	0.001	0.001	0.001
Low rainfall/Aridity	0.01	0.01	0.01	0.1	0.001	0.01
Unusual Rainfall	0.01	0.1	0.1	0.01	0.001	0.01
Heavy Rainfall	0.1	1	0.1	0.01	0.1	0.01
Drought	0.001	0.001	0.01	0.001	0.001	0.001

Note: 1 = High, b) 0.1 = Moderate, c) 0.01 = Low, and d) 0.001 = Very Low.

The main findings of the PVA exercise in Noakhali, aggregated for all 21 Unions, can be recapitulated as follows:

- water logging and drainage congestion are the main problems; re-excavation of canals and restrictions on unplanned construction of roads and infrastructure are recommended
- the number of cyclone shelters is not adequate and there is no existing provision for sheltering livestock; the people suggested building *killas* (raised earthen platforms for livestock)
- there are no disaster management committees in most unions and the ones that exist do not function; these committees have to be constituted or revamped; they should be provided with mikes (sound installations), equipment, medical facilities and training
- cropping patterns are seriously affected by salinity intrusion, as well as waterlogging (long periods of inundation); a shift towards salt tolerant varieties of crops and winter vegetables were suggested as alternatives
- medical facilities are not adequate and Upazila Health Complexes are not equipped with doctors, facilities and medicines; fully functional mobile hospitals, especially for women and children were recommended by many.

Over the years, the coastal people have acquired some coping strategies to adapt to the situation they often face. These strategies cover a broad spectrum of activities; some focus on preparedness, while others enable them to tackle the aftermath of disasters. A number of indigenous coping strategies were identified and recorded during the PVA exercise. These strategies are 'home-bred' and exclusive to the people living in the coastal areas of Noakhali. A brief description of the coping strategies is listed below:

- Distress selling is the most common coping strategy, when people sell their assets, valuables and livestock
- Women store rice, about a handful a day, in the false ceiling of their homes (locally known as *macha*) throughout the year for emergency times
- Kerosene oil containers (made of tin) are used as portable cooking stoves during floods
- Cow dung is made into dry cakes and stored as fuel, along with dry leaves and twigs
- Tools are stored for repairing houses, including plastic ropes and bamboo; houses are often tied to big trees with strong branches
- Women store their jewellry and precious belongings in plastic bags and store them underground
- Toilets are made in less inundated areas and often this means building a *shanko* or a small platform made with bamboo
- Children carry a change of clothes while going to school, during the rainy season and floods
- Many of the villagers try to keep water from entering their homesteads by placing banana stumps on the entrance and using them as rafts for commuting from one place to another

The PVA conducted in Noakhali also identified the role of local government agencies as 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 the sectors of agriculture, fisheries and disaster management, where local agencies can play an important role.

10.4.2 Demonstration of Disaster Resilient Structures

IUCN Bangladesh, with financial assistance from the Netherlands Climate Change Assistance Programme (NCAP) carried out two action research activities in Noakhali. These activities resulted in basic structural modifications for making homes and fishing boats more resilient to natural disasters. A total of six disaster resilient homes, two schools and six fishing boats have been reconstructed, strengthened or modified after extensive consultations amongst community members, local masons and carpenters, and architects from reputed universities.

Plagued by natural disasters, the common rural housing structures in coastal Noakhali are ill-equipped to withstand strong winds, let alone the ferocity of a cyclone. Sections of the house like the roof are particularly vulnerable. Insects, dampness and rainwater are phenomena that further endanger the structural integrity of houses. Weak sections of the house susceptible to such dangers are strengthened with affordable, yet durable, construction materials such as mud, tin and bamboo. Keeping in mind the financial state of the community greater emphasis was given to repair rather than reconstruction.

The designs of these homes were adapted from rural traditional designs, with few modifications suggested by architects from BRAC University. These homes are erected on disaster (cyclone and flood) prone areas, belonging to hard core poor and landless households. In order to ensure better health of school-going children, sanitation facilities at low costs were also installed in the schools, along with supply of safe water. CDSP–III working in Boyer Char in Noakhali has already taken up the designs (demonstrated by IUCN–B) for replicating them in their own project area. The robustness of the improved disaster resilient homes has been tested; they were able to withstand a wind velocity of about 220 km/hr during the recent cyclone Aila, which hit the coastal area of Bangladesh in 2009.

Fishermen in recent years have been facing extreme weather conditions, with many incidents of capsizing boats. With the onset of harsher seas, the already structurally inefficient fishing boats in the region were becoming obsolete. During low tides the sand dunes are at closer proximity to the waters surface. The crest of the wave carries the boat upwards and smashes it hard with the trough onto the unforgiving dune. The sea is increasingly becoming rough and fishermen are losing their capital and livelihoods due to the number of days they are forced to remain on shore.

Design modifications were carried out on six coastal fishing boats and trawlers in Noakhali. The designs of these boats were modified after extensive discussion and case studies by marine architects from BUET; local fishermen and boat builders were involved in the entire process. The most pragmatic solution was the use of steel to reinforce weak segments of the boat; the reinforcement made the planks of the boats stronger. These sea-going boats and trawlers are fully functional in the Bay of Bengal and Hatiya channel in Noakhali and till date no incidents of capsizing were reported.

10.4.3 Promoting Alternative Cropping Patterns

Agriculture is one the main drives of development in the coastal regions of Noakhali. Manifestations of climate change such as salinity intrusion pose one of the biggest problems to the livelihoods of farmers, especially the marginal farmers and share croppers. IUCN Bangladesh has been working 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 rice species. The pilot research was conducted in four villages of Noakhali, representing different agro-ecosystem types, mainly saline affected and waterlogged areas. The approach was highly participatory in nature, so that new varieties and farming techniques were readily accepted by the beneficiaries and there would be significant changes in their livelihoods and nutritional status. The involvement of DAE staff and local people, especially in testing this new variety, was ensured, so that such initiatives are sustainable in that area.

Another IUCN–B study revealed that, in Noakhali, farmers are now willing to try alternative crops such as sweet potatoes, watermelon, and other seasonal vegetables like eggplant, cucumber, soy beans, gourds, lemon, cauliflower, tomato etc. According to the farmers, these crops are profitable and there is a high market demand both locally and in the big cities. In order to minimise the loss in yield due to changes in climatic patterns, local farmers have taken up these new crops to support their livelihoods.

There are a number of indigenous techniques that the farmers have already been practicing in Noakhali, namely, mixed cropping (cultivation of various vegetables, spices in a single piece of land) and cultivation of rice and fish together locally known as *bajal*. Locally, people are motivated and need appropriate training and technology transfer. Field level extension officials can play a catalytic role in creating such linkages and promoting rural livelihoods.

10.4.4 Communicating Climate Change through School Children

IUCN Bangladesh in association with the Char Development and Settlement Project (CDSP)–III undertook to raise awareness and educate the children of coastal communities on issues of climate change, with special focus on adaptation. The approaches included art and essay competitions, children's book and teacher's guide on climate change, staging of a folk drama, documentary presentations, poster and sticker printing, creation of a mascot and so on. School visits and sessions with children, awareness programmes 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.

The targeted schools under this initiative were selected on the basis of schools' inclination to work on an awareness and physical accessibility to the schools. A total of 15 schools and *madrasas* were involved, from four Upazilas of the Noakhali District, as illustrated in the Table 10.2.

IUCN Bangladesh led the initiative to stage a drama titled 'Ebar Rana Bhai Bolchen' (Let's hear Rana Bhai). The performance was conducted by a total of 18 children form grades 6 to 10 at the Obaidullah Memorial High School in Sadar Upazila of Noakhali. The show was staged as an informative and fun way of educating coastal communities, especially children, on the threats posed by climate change. The children were involved in the process of script writing, dialogues, music composition, songs etc. It was a 'participatory drama', where children expressed their views and opinions and edited the script and other details as they saw fit. The folk songs used in the drama was also selected by the performers.

10.4.5 Rana Bhai Mascot as an Ambassador of Climate Change

Inspired by the success of 'entertainment education' of UNICEF's *Meena Communications Initiative*, IUCN Bangladesh in partnership with CDSP–III has

Table 10.3. List of schools under the IUCN,B and CDSP-III initiative

Upazila Sadar	Number of schools	Names
	3	1. Obaidullah Memorial High School
		2. Ishakpur Major Mannan High School
		3. Keramotia *Madrasa*
Subarnachar	4	1. Purba Char Bata High School
		2. Char Clark High School
		3. Shahid Jainal Abedin High School
		4. Zubair Bazar Junior High School
Kabir Haat	3	1. Miah'r Haat High School
		2. Kabir Haat High School
		3. Chaprashir Haat High School
Hatiya (including Boyarchar)	5	1. Sukhchar Union Bangabandhu High School
		2. A. M. High School
		3. Boyar Char Junior High School
		4. Nabinagar Konpolin Primary School
		5. Jahajmara High School

piloted a number of communication materials, using the mascot 'Rana Bhai'. Rana Bhai with his sunny disposition is 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 centrepiece 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, has been added to his name to establish a warm brotherly relationship with the children.

The drama 'Let's hear Rana Bhai' has been filmed. Rana Bhai is the amphibious equivalent to the nutty professor. His appearance on stickers, posters and books advocate climate change adaptation messages and encourage school children to discuss adaptation measures with their families and friends. Rana Bhai's role is two-fold, firstly to motivate children to engage adaptation measures within their communities, secondly to encourage them to spread the word amongst other children and amongst parents.

Rana Bhai, the climate change mascot is also the star of his own documentary on climate change targeted at school children. The documentary essentially describes the project's activities and strives to deliver the message of climate

change in an entertaining and amusing format, as the targeted audience consists mostly of children.

10.5 ROLE OF LOCAL GOVERNMENT AGENCIES AND FIELD INSTITUTIONS IN FACILITATING ADAPTATION

Given the mammoth complexity and the diversity of climate changed induced hazards, and implications for lives and livelihoods of local communities, it is difficult for the communities alone to face its manifold challenges. As shown in the earlier sections, communities have devised their own mechanisms to cope with climate change, in a basic and limited way. Initiatives developed and implemented in consultation and with their involvement, have resulted in stronger houses, fishing boats and changes in cropping patterns. Given the seriousness of the issue at stake, it is vital that coastal settlers are given the opportunity to have links with knowledge and skills from beyond their communities. Local initiatives and indigenous knowledge need to be complimented by a proactive and supportive role from other sectors and levels of the society.

In order to remain closer to the field, institutions such as Water Management Organisations (WMOs), Social Forestry Groups (SFGs) and NGO-groups are in a unique position to form the initial linkages with the upper tiers of the administration. These community based organisations can interact with, for instance, local government and state agencies. It is the responsibility of the local government and associated agencies in the field to raise awareness and develop strategies to reduce the vulnerability of high risk communities. 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 forth to aid the development schemes.

During the planning and implementation of all the local level interventions carried out by IUCN Bangladesh in Noakhali, the local government has been involved and sensitised. They have been one of the most important stakeholders in the selection of sites, beneficiaries as well as the awareness raising initiatives. For instance, Upazila and Union Parishad representatives were provided with basic knowledge on climate change and disasters, and with the results of scientific studies carried out in their region. People in the coastal areas 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 the transfer of technology, as observed in Noakhali.

10.6 EPILOGUE: LESSONS LEARNT, REPLICATION AND SCALING UP

In this concluding section, an attempt is being made to recapitulate the preceding observations and experiences. It shows that some lessons learnt through the process of engaging communities in vulnerable and disaster prone areas.

10.6.1 Support for People's own Adaptation Strategies

The coastal area of Noakhali, from where much of the experience was gained, is a low lying, saline and flood prone area. Inhabitants face a multitude of vulnerabilities that will be exacerbated due to the impact of climate change and climate variability. People are already observing changes and anomalies in rainfall patterns, temperatures and extreme weather events. As a response, they have already started adapting and modifying their lifestyles to cope with the changes. In order to broaden their adaptation related activities, support was provided to link people's perceptions with knowledge and skills from the rest of the country. Central to these efforts were structural improvements in houses and boats, alternative cropping patterns and awareness creation.

10.6.2 Alternative Cropping Patterns

People's vulnerability can be reduced by bringing about new and alternative crops suitable for those areas (varieties of rice that can withstand water and salinity). Research on the soil suitability and cropping patterns in Noakhali and other coastal areas needs to continue and to be expanded to similar terrains. Areas not protected from the sea, for instance newly accreted chars, should be included in such research initiatives. A participatory approaches should be applied to disseminate the research results and apply them practically.

10.6.3 Houses with Improved Designs

The houses with improved, disaster-resilient designs can be replicated in other coastal areas of Bangladesh. In order to ensure acceptability among the local people, area based minor modifications could be introduced in the designs. Field testing for newer areas is necessary, along with some surveys and discussions with local settlers, masons and carpenters.

10.6.4 Training of Fishermen and Supply of Equipment

Fishermen in the coastal areas need to participate in awareness and skill development programmes. They need to be trained not only on the physical structures and improved designs of boats, but also on the interpretation of cyclone signals, warnings and forecasting. The coastal fisher folk, who venture out to the open and rough seas, also need to be equipped with radio, lifebuoys and emergency supplies.

10.6.5 Raising Awareness at All Levels

Wider awareness at all levels is absolutely essential, for all stakeholders, whether primary (such as coastal communities) or secondary (such as government institutions). Specific and appropriate awareness raising packages need to be designed for schools, local government, local administration, policy makers, with special emphasis on women, since the brunt of climate change will fall on them disproportionately. Currently, there are printed materials available, such as students' pictorial books on climate change. Efforts should be made to disseminate these widely, to all schools of in the greater Noakhali region.

Field level institutions such as WMOs, SFGs and NGOs must be made aware of their crucial role as the conduit between local coastal communities and local government, state agencies and further in the chain to knowledge based organisations. Local government bodies in general need to be strengthened and sensitised to take up a more proactive role. Environmental committees at the Union Parishad level exist, but in order to facilitate adaptation to climate change, their roles and responsibilities need to be redefined. The environmental committee members also need to be equipped to influence decision making and incorporate local level concerns related to climate change into the development plans. A wide range of strategies and messages has to be developed, based on available, proven and effective methodologies.

10.6.6 Fortify People's Resilience

Throughout history, the people of Bangladesh have shown their courage and innovative mind in fighting against all odds and wrath of nature. It is expected that alternative development interventions will fortify people's adaptation strategies and foster a future generation able to cope with climate change and variability.

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Chapter 11

Climate Change, Bangladesh and the Estuary

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11.1 INTRODUCTION

At many places in this book, climate change an 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 (Section 11.3), and on the consequences of these foreseen developments for the coastal zone in general and for the estuary (Section 11.4). The chapter closes with concluding remarks in Section 11.5.

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 Organisation and of the United Nations Environment

Programme 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 Fourth Assessment report of IPCC was published in 2007. IPCC concluded that the evidence that climate change is already occurring is unequivocal and is due in large part to human activity. The IPCC says that the world faces an average temperature rise of around 3°C this century, if greenhouse gas emissions continue to rise at their current pace and are allowed to double from their pre-industrial level. The impact of this climate change on natural and human systems around the world is already being witnessed, in particular as a consequence of the rise in average temperatures. Since 2007, reports comparing the IPCC projections of 1990 with empirical evidence, show that some climate indicators are changing near the upper end of the range indicated by the projections made at the time. The projected rise in sea level is a case in point.

The prediction of global sea level rise as given in IPCC's Fourth Assessment Report is shown in the Figure 11.1. It is predicted that the sea level will rise up to 59 cm by 2100. The prediction is based on the so called IS92a scenario, one of the six alternative scenarios (IS92a to f) that were published by IPCC in 1992. The scenarios represent a wide range of CO_2 emissions. The assumptions for the IS92a scenario came mostly from the published forecasts of major international organisations or from published expert analyses. The assumed level of CO_2

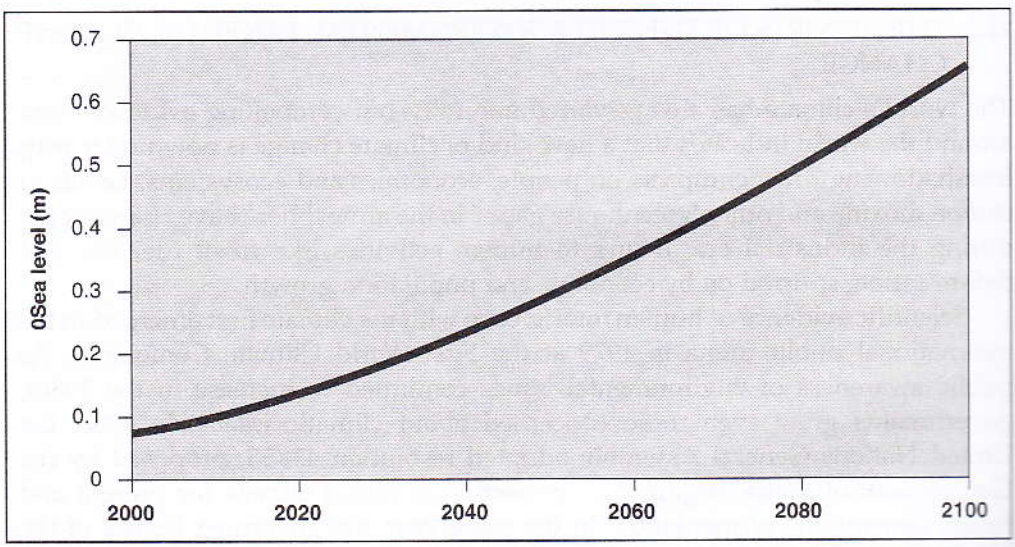

Figure 11.1: Prediction of global sea level rise according to IS92a scenario

emission lies between the highest and the lowest assumptions in the whole spectrum of the six scenarios. This particular scenario has been widely adopted as a standard scenario for use in impact assessments.

As mentioned, predictions have been updated since 2007. In the so called Synthesis Report of 2009, the IPCC states that the sea level is likely to increase by 1 meter by 2100, 41 cm more than earlier thought.

The IPCC, using a range of model projections, has asserted in the 2007 report there is a probability greater than 66%, that continued sea-surface warming will lead to tropical cyclones that are more intense, with higher peak wind speeds and heavier precipitation.

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 summarised 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, and cyclones is given below, in Sections 11.2.2 and 11.2.3 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. 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 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°C 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.

Projections for the future

The median predictions from the General Circulation Models are for Bangladesh to be 1.5°C warmer and 4% wetter by 2050. The General Circulation Model is a numerical model, designed for study of the atmosphere, ocean and climate.

In its 4th Assessment Report, IPCC provides a projection of changes in surface air temperature and precipitation for South Asia, under two different scenarios (see Table 11.1). The first scenario (Sc 1 in the Table) is based on a highest future emission of greenhouse gases trajectory, while the second one (Sc 2) is based on the lowest future emission trajectory.

Table 11.1: Projected changes in surface air temperature and precipitation for South Asia for three time slices

Mnth.	2010 to 2039 (2020s)				2040 to 2069 (2050s)				2070 to 2099 (2080s)			
	Temperature °C		Precipitation %		Temperature °C		Precipitation %		Temperature °C		Precipitation %	
	Sc 1	Sc 2	Sc 1	Sc 2	Sc 1	Sc 2	Sc 1	Sc 2	Sc 1	Sc 2	Sc 1	Sc 2
DJF	1.17	1.11	-3	4	3.16	1.97	0	0	5.44	2.93	-16	-6
MAM	1.18	1.07	7	8	2.97	1.81	26	24	5.22	2.71	31	20
JJA	0.54	0.55	5	7	1.71	0.88	13	11	3.14	1.56	26	15
SON	0.78	0.83	1	3	2.41	1.49	8	6	4.19	2.17	26	10

Notes: DJF: December-January-February; MAM: March-April-May; JJA: June-July-August; SON: September-October-November.

Table 11.1 shows that in both scenarios precipitation will increase quite steeply in March, April and May, ranging from 7% in the 2020s to 31% in the 2080s. Rainfall in the monsoon period (June, July and August) will also be higher, but the increase will be less compared to the March to May period. The December to February period will be drier in scenario 1 (high level of emissions). Scenario 2 gives the same trend towards the 2080s, but less pronounced. Both scenarios give an upward trend in temperature, with, as expected, sharper increases in scenario 1 (over 5 degrees Celsius from December to May).

11.3.3 Cyclones

Recent scientific studies have suggested that in the past 35 years, the frequency and the intensity of tropical cyclones have increased. According to the 2007 IPCC report, a further increase of 10 to 20% in tropical cyclone intensities for a rise in sea-surface temperature of 2 to 4°C relative to the current threshold temperature, is projected for East Asia, South-East Asia and South Asia. Amplification in storm-surge heights could result from the simultaneous occurrence of stronger winds and higher sea-surface temperatures. This would result in an enhanced risk of coastal disasters along the coastal regions of East-, South-East and South Asian countries, including Bangladesh.

11.4 MAIN CONSEQUENCES FOR THE COASTAL ZONE AND THE ESTUARY

11.4.1 Water Logging

Bangladesh started a programme 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 125 polders having 5,017 km of embankments, of which 957 km enclose 49 sea-facing polders and the remaining 4,060 embankments enclose 74 interior polders. These embankments protect around 1.5 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 Baggerhat 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 tectonic activities, compaction of peat layers and human activities. 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 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 climate resilient adaptation measure for solving water-logging problems. The method is technically and economically feasible, and environmentally friendly.

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.

Over the last 49 years (1960-2009), 19 severe cyclones hit the coast of Bangladesh. In recent years, 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. 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 km^2 of land, and greater than 3 meters in 10,163 km^2. 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 11.2 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 11.2: 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 freshwater 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.

11.5.1 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.

11.5.2 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 programme. Such programmes should be embedded in an effective institutional environment.

11.5.3 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.

11.5.4 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

Conclusion: Taking Stock and Looking Forward

Koen de Wilde

12.1 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 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.

12.2 FORMATION 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 1.1 billion 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 20 km^2: newly formed land of about 52 km^2 minus eroded land of around

32 km². The accretion seems to be accelerating over the past decade. The accretion dominated around islands south and south-east of the Noakhali mainland, and south-west of Bhola.

It is standing policy to transfer newly emerged chars to the Forestry Department for a period of 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 fifty years, the coastal area under forest increased with about 150,000 hectares. Actual plantations were about double that area, but much got destroyed due to erosion and human encroachment. 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.

Once the 20 year period 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.

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.

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). *Operation and maintenance* is therefore a major issue that has to be vigorously addressed.

In the chars, a transition in *aquatic livelihoods* can be witnessed, that can be summarised as a movement from capture to culture. 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 *khals* 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, because ponds are safe from flooding. Based on field experience, key factors for aquaculture in ponds are: an appropriate pond preparation, a 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. If extension services are improved, productivity can be raised.

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, but poultry gains in relative importance within polders. There is considerable room for improvement in the rearing systems in the chars. 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 have to 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 many 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 irrigation in char areas elusive. The embargo is based on the uncertainties of the effect of groundwater extraction on intrusion on saline sea water. 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 long term trend is downward, with periods of increases in salinity making the trend quite erratic. Certain cultural techniques can help to reduce or cope with soil salinity. Research that is more targeted to the problems in coastal areas and improved extension services, will help the agricultural sector to develop.

12.3 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. The average yearly erosion amounts to 32 km^2, which means that, with an assumed density of 800 people per km^2, each year approximately 26,000 people (about 4,500 households) will lose their land in the estuary. 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 *jotdars* and their *bahinis* 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. There is no access to drinking water, especially in winter and no 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

have to face 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 remaining 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 organisations established by state agencies through a number of development projects. Good examples are the Water Management Organisations, Farmer Forums and Social Forestry Groups. Also NGOs will move in and start their livelihood oriented programmes, 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 organisations and the communities. The quality of the relations between local government, state agencies and community based organisations 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.

The higher institutional density (increase in presence of government, birth and growth of a series of community-based organisations and establishment of private sector institutions), the greater social cohesion among households, the progress in economic terms, 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 and often significantly improve their livelihoods.

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.

People have already experienced and recognised 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.

12.4 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 factors will provide the required information and data necessary for a responsible analysis. These factors 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.

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 (estimated at 1 to 1.5 cm per year), 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. 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 sea level rise induced by 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 in size. 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 analysing 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 because of climate change. 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, and maximum fresh water storage 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.

12.5 AN AGENDA FOR THE FUTURE

12.5.1 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 programme 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 programme. Effective institutional arrangements

should be put in place for the implementation of the survey and monitoring programme, for the processing and analysis of the collected data, and for the translation of these data into realistic policy recommendations.

12.5.2 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 programme of land accretion schemes should be taken up as priority, while surveys to identify new potential land accretion areas have to be carried out.

12.5.3 Undertake Feasibility Studies for Areas that can be Brought under Social Forestry

With a view on climate change, the value of mangroves can hardly be underestimated, especially their property of protecting the coast against cyclones and storm surges. Forests enhance carbon sequestration, contribute to the stability of newly formed land, add organic matter to the soil and can generate an income stream for households. It is estimated that around 4.65 million hectares are available for afforestation in the whole of the country. A study should be commissioned with the aim of identifying the available land in the coastal zone where forests could be planted, based on the principles of social forestry. Money to implement such a forestation programme could come from the various climate change funds, while also public/private partnerships should be considered.

12.5.4 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, has to 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.

12.5.5 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.

12.5.6 Review Design Criteria and Give more Attention to Operation and Maintenance (O&M)

To address climate change related phenomena (higher sea levels, more and stronger storms and storm surges, erratic rainfall), current design standards for a broad range of infrastructure have to be reconsidered 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. 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 for O&M for the main infrastructural agencies therefore have to be increased, while households and local government have to bear a share of the burden. Cooperation between government agencies, communities (especially Water Management Organisations) and local government has to be promoted. Multi-year maintenance agreements between those parties will come a long way in fostering and structuring this cooperation.

12.5.7 Continue with Formation of Field Level Institutions

Field level, community-based organisations, 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 programmes, local organisations such as Water Management Organisations, 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. The links between field level institutions and the private sector is an issue deserving attention.

12.5.8 Raise Awareness at All Levels

Wider awareness about causes and consequences of climate change is absolutely essential. A campaign should be designed and implemented with targeted activities for a wide range of institutions, ranging from schools to the central government, and from local government to the media. Community based organisations must be made aware of their crucial role as the conduit between local coastal communities and local government, state agencies and further in the chain to knowledge based organisations. They are well placed to emphasise the importance of support for the adaptation strategies started by the people of coastal communities themselves.

12.5.9 Support a Process of Decentralisation and 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 decentralisation in order to give the local government the resources and the institutional room to execute its functions.

12.5.10 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, ecological processes in the mangrove habitat, screening of crops and crop varieties against soil salinity, 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. Organisations should embark on a system of courses and refresher courses for their own staff to disseminate newly developed knowledge. Policies ad the design of programmes should become more knowledge based.

12.5.11 Work on a Long-term Regional Plan for the Estuary

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. The Plan identifies the Meghna Estuary as one of the planning units. Such a regional plan for the estuary could be prepared in the ICZM framework, if this framework is indeed made operational. It could result in a broad range of measures, from monitoring programmes to integrated development interventions, and from engineering works to awareness raising campaigns.

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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. Currently, he is Chief Technical Adviser of CDSP III, on a contract with Euroconsult Mott MacDonald.

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