BANGLADESH FLOOD ACTION PLAN

Ministry of Water Resources
Flood Plan Coordination Organization (FPCO)

Charland Summary Report

April 1995

Prepared by

Environmental Study (FAP 16)

Geographic Information System (FAP 19)

ISPAN

IRRIGATION SUPPORT PROJECT FOR ASIA AND THE NEAR EAST

Sponsored by the U.S. Agency for International Development

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PREFACE

This summary report is based on a the series of reports covering the immediate riverine lands of the major rivers of Bangladesh—the Jamuna, Ganges, Padma, and Meghna. Riverine charlands are defined in this study as areas frequently subject to erosion and accretion within and adjacent to the main rivers of Bangladesh and unprotected by embankments. The study was carried out by ISPAN under Flood Action Plan Supporting Studies FAP 16 (Environmental Study) and FAP 19 (Geographic Information System).

The full set of reports is shown in the table below.

Overview Reports	Inventory Reports	Other Reports
Charland Summary Report	The Dynamic Physical and Human Environment of Riverine Charlands: Brahmaputra-Jamuna	Upper Jamuna (Brahmaputra) Charland Socio-Economic RRA
Charland Socio-Economic Summary Report	The Dynamic Physical and Human Environment of Riverine Charlands: Meghna	Middle Jamuna Charland Socio-Economic RRA
	The Dynamic Physical and Human Environment of Riverine Charlands: Padma	Upper Meghna Charland Socio-Economic RRA
	The Dynamic Physical and Human Environment of Riverine Charlands: Ganges	Meghna Confluence Charland Socio-Economic RRA
		Padma Charland Socio-Economic RRA
		Ganges Charland Socio-Economic RRA
		Charland Flood Proofing Study

ACKNOWLEDGEMENTS

This report is the result of a team effort involving many of the staff of both FAP 16 and FAP 19, which was coordinated by Dr.Keith Pitman, Chief of Party, ISPAN. It has depended heavily on field work undertaken by about 16 enumerators organized through a fieldwork contract with Development Planners and Consultants.

The inventory study was coordinated by Paul Thompson. Aminul Islam assisted with survey design, Sachindra Halder, Golam Monowar Kamal, and Shanawaz Siddiqui supervised the 1993 surveys. Mamoon Hamid and Qazi Salimullah were responsible for the databases and tables. Abdul Matin Miazi prepared the inventory derived maps. Tim Martin was responsible for overall supervision of the FAP 19 team. David Savory was responsible for the image analysis and GIS work, which was started up by Mike Pooley. Iffat Hoque undertook the image analysis. Colin Thorne contributed to interpretation of channel dynamics and river morphology. The following worked on the GIS and mauza digitization: Nazmul Alam, Mustafa Kamal, and Nasreen Khan. Several members of the FAP 19 team carried out ground truthing.

The socioeconomic study was jointly coordinated by Dr. Mustafa Alam and Dr. Suzanne Hanchett. The flood proofing study was jointly coordinated by Paul Thompson and Ian Todd. Both studies involved very intensive fieldwork under rather difficult circumstances, and those who performed this work are gratefully acknowledged. The contents of those reports are based primarily on information obtained from people living in the charlands, all of whom were extremely helpful in patiently providing the necessary information. Interviews were also held with government officials and NGO field workers. The cooperation of all these participants is also gratefully acknowledged.

We are grateful to the Flood Plan Coordination Organization and to its Panel of Experts for providing overall direction to this study. The assistance of FAPs 1, 2, 3, 3.1, 4, 5, and 25 is also gratefully acknowledged.

GLOSSARY

acre	-	Acre = 0.4047 ha
aman	-	Late monsoon season paddy planted before or during the monsoon and harvested November-December
aratdar	-	Wholesale trader with warehouse
aus	-	Early monsoon paddy planted in March-April and harvested in June-July
B. aman	-	Broadcast aman paddy, usually grown in deeper water
babla	-	Gum arabic tree
BARC	-	Bangladesh Agricultural Research Council
bari	-	A homestead, usually consisting of more than one structure arranged around a central common area
BBS	-	Bangladesh Bureau of Statistics
BDR	-	Bangladesh Rifles
beel	-	An area of open water away from a river
BIDS	-	Bangladesh Institute of Development Studies
bigha	-	A local unit of area most commonly equalling 0.33 acre or 0.14 ha
boro	-	Dry season paddy transplanted in December-January and harvested in April-May
BRAC	-	Bangladesh Rural Advancement Committee
BTM	-	Bangladesh Transverse Mercator (map projection)
BUET	-	Bangladesh University of Engineering and Technology
BWDB	-	Bangladesh Water Development Board
china	-	A variety of millet
chowki	-	Bed/platform
cumecs	-	Cubic meters per second
dacoit	-	Bandit
dal	-	Any of a variety of pulses (lentils); a high-protein food staple usually eaten with rice
decimal	-	Unit of area equal to 0.01 acre
DEM	-	Digital elevation model
dhaincha	-	A nitrogen-fixing plant used as live fencing, fuel, and building material
district	-	A large administration unit under the authority of a Deputy Commissioner, now known as a zila
EIA	-	Environmental Impact Assessment
FAP	-	Flood Action Plan
FCD/I	-	Flood Control and Drainage or Flood Control, Drainage, and Irrigation
FPCO	-	Flood Plan Co-ordination Organization
FWC	-	Family Welfare Centre
GIS	-	Geographic Information System
GPS	-	Global Positioning System
gur	-	Locally produced molasses
haor	-	Deeply flooded basin of NE Bangladesh
hat	-	Periodic market
hectare (ha)	-	Hectare = 2.4711 acres
hogla	-	A bullrush (*Typhus angustata*) used for making mats
HSC	-	Higher Secondary Certificate
HTW	-	Hand tubewell

HYV	-	High Yielding Variety
jangal	-	Ground cover shrubs used for fuel and as herbs
jhau	-	Tamarisk bush used as fuel and an herb
JPPS	-	Jamalpur Priority Project Study
kaisa	-	A variety of catkin grass (*Saccharum sp.*) giving up to three cuttings a year
kani	-	Local unit of measure equal to .13 ha (.33 acres)
kash	-	*kaisa*
kayem	-	Permanent or old
kaon	-	Fox-tail millet
khas	-	Publicly owned
kheya	-	Local boat landing point
khal	-	A drainage channel or canal either natural or man-made
kharif	-	Summer/wet season
kilogram (kg)	-	Kilogram = 1.11 sheer
kilometer (km)	-	Kilometer = 0.625 miles
kobiraj	-	Traditional healer
kutcha	-	Flimsy construction of a temporary nature, in the chars usually of grass, bamboo, straw, or similar materials
macha	-	A raised platform
mashkalai	-	A type of pulse (lentil); see *dal*
matabar	-	Leader of the local community
maund	-	A unit of weight, 1 Maund = 40 sheer = 37.5 kilograms
mauza	-	A village revenue collection and cadastral mapped unit
MCSP	-	Multipurpose Cyclone Shelter Program
mile (mi)	-	Mile = 1.6 kilometers
MPO	-	Master Plan Organization (of Ministry of Irrigation Water Development and Flood Control)
MSS	-	Multi-Spectral Scanner (Landsat satellite sensor)
musur	-	A type of pulse (lentil); see *dal*
nara	-	Straw
NGO	-	Non-Government Organization
paiker	-	Wholesale trader
para	-	Neighborhood
PoE	-	Panel of Experts (of FPCO)
pourashava	-	a municipality, usually the urban center of a district
pucca	-	Sturdy construction of a permanent nature, usually of such materials as brick, concrete, or corrugated iron sheets
rabi	-	Winter/Dry Season
RDRS	-	Rangpur Dinajpur Rural Service (an NGO)
return period	-	average interval in years between floods of a given magnitude
RRA	-	Rapid rural appraisal
sadar	-	The urban core (administrative headquarters town) of a thana or district
salish	-	local informal court
samaj	-	Society, community; a formal arrangement between members of a community whereby each member has certain rights and privileges
SCI	-	Service Civil International (an NGO)
sheer	-	A unit of weight = 1/40 maund = 0.94 kg
shon	-	A variety of grass (*Imperata cylindica*) giving one cutting a year

SPARRSO	-	Space Research and Remote Sensing Organization
SPOT	-	System Pour Observation de la Terre
SRDI	-	Soil Research Development Institute
SSC	-	Secondary School Certificate
Taka (Tk.)	-	Bangladesh currency, US$ 1 equalled approximately Tk. 40 in late 1992-early 1993
T. aman	-	Transplanted aman paddy
thana	-	A sub-division of a zila, or district
TM	-	Thematic Mapper
ton	-	An imperial ton = 1,016 kg
til	-	Type of oil seed
union	-	Sub-division of a thana, formerly known as upazila
upazila	-	Previous name for a thana (subdivision of a zila or district)
ustha	-	Bitter gourd (*Momardica charantia*)
WHO	-	World Health Organisation
zila	-	A large administration unit formerly known as a district

EXECUTIVE SUMMARY

1. Background

The residents of chars and the mainland adjacent to main rivers of Bangladesh have a precarious existence, subject as they are to erosion and flooding that can destroy crops and homesteads, render land unproductive, and kill livestock. In short, they are among the most hazard-prone people of Bangladesh. Structural flood protection is unlikely to benefit these people, and embankments may even increase the risks to which they are exposed by raising flood levels.

In 1992 the Irrigation Support Project for Asia and the Near East (ISPAN), on advice from the Flood Plan Coordination Organization (FPCO) and through a joint effort of the Environmental Study (FAP 16) and Geographic Information System (FAP 19), undertook a study of the resources and people in the chars of the Brahmaputra-Jamuna, Ganges, Meghna, and Padma rivers.

The Charland Study has two objectives. The first is to develop databases and a geographic information system (GIS) that can be used as planning tools both for direct interventions in the charlands and for other interventions (such as embankments) that may affect the char areas. The second objective is to use the data collected, along with additional socioeconomic studies, to make general policy recommendations for the charlands and to test and develop means of rationally identifying potential flood proofing measures and assessing their potential benefits in these areas.

Five tasks have addressed these objectives.

- Making an inventory of resources, people, and infrastructures in the Brahmaputra-Jamuna, Meghna, Padma, and Ganges charlands and collecting additional information on hazards (led by FAP 16).
- Using digital satellite images to analyze physical changes and land use in these areas, and integrating this analysis with inventory data using a GIS (FAP 19).
- Conducting supplementary socioeconomic studies using rapid rural appraisal (RRA) methods in six river reaches (building on the Flood Response Study, FAP 14).
- Conducting detailed studies of flood losses and flood proofing potential in two areas along the Jamuna River (building on the Flood Proofing Study, FAP 23).
- Integrating the results of the above tasks into a comprehensive report.

This document summarizes the overall findings of the study, concentrating on the inventory results and a comparative analysis of the charland data of the four rivers studied. Information from the Socioeconomic Study Summary Report, the Socioeconomic Study RRAs, and the flood proofing surveys is summarized where appropriate. This report includes recommendations and guidelines based on all the Charland Study components.

2. Definition of Charland

This study is primarily concerned with riverine charland, the Bengali term for a "mid-channel island that periodically emerges from the riverbed as a result of accretion" (Elahi *et al.*, 1991), and more generally with the active floodplain, which is subject to erosion and accretion. Additionally, some mainland adjoining the main rivers, while not chars in the above sense, is also at risk from bank erosion and is just as flood-prone as the chars. These areas were included in the study.

Land and mauzas in the study areas were classified into the following three main types (subdivided by left and right bank as appropriate):

- Island chars.
- Right and left bank attached charland.
- Right and left bank unprotected mainland.

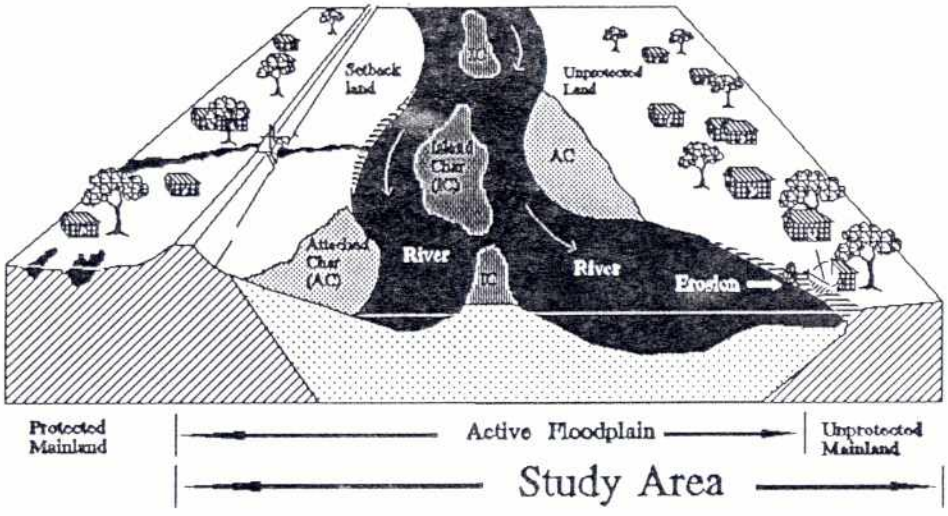

Figure 1 Charland Classification

The figure above illustrates this classification system, which was developed for the charland inventory.

For this classification, island chars are defined as land that, even in dry season, can only be reached by crossing a main river channel. Attached charland is accessible from the mainland without crossing a main channel during the dry season (crossing lesser channels may be required), yet is inundated or surrounded by water during the peak of a "normal" flood (normal monsoon). Setback land is mainland on the river side of flood protection embankments. It differs from other unprotected mainland because the embankments may provide refuge during floods but may also constrain flood water, thereby raising flood levels. Unprotected mainland has no embankment between it and the main river and is inundated during higher than normal floods. Unprotected mainland has been surveyed up to the extent of recent floods or features, such as roads, that restrict flooding.

3. Findings

The study covered an area of 8,444 km^2 (almost 6 percent of Bangladesh), and it was dominated by the Brahmaputra-Jamuna charlands, which accounted for 45 percent of the area covered. The Brahmaputra-Jamuna and Meghna are each about 50 percent island or attached char mauzas, and in the Ganges and Padma, more than 70 percent of the total area is in unprotected mainland mauzas. Based on the dry season satellite images, the proportion of the charland area that is usable (vegetated or cultivated land) is remarkably consistent between rivers, averaging 63 percent.

Almost 4.3 million people lived in the active floodplain of these four rivers in 1992-93, the majority of them along the Jamuna and Meghna. Of the total floodplain population, 1.85 million (43 percent) live on chars, and they are concentrated in the Jamuna and Meghna. Because of high populations on island chars in these two rivers, 50 percent of the population covered lives on chars. In the Jamuna they are spread along the length of the river, but in the Meghna they are concentrated in the confluence and lower reach. These two rivers are the only ones where the island char population grew after the 1981 census. The island char populations of the Ganges and Padma fell during this period as a result of morphological changes and channel widening.

During the past decade or so, all four rivers have tended to widen and take on more braided forms. Landsat image analysis gives an estimate of almost 87,000 ha lost due to bankline erosion (net of accretion), more than 50 percent of which was along the Brahmaputra-Jamuna. On average, about 8,700 ha of mainland are lost each year to erosion

by the main rivers. Within-channel changes, however, result in replacement of mainland by chars: more than 50,000 ha of char accreted (net) between about 1984 and 1993.

Average annual erosion rates vary greatly between rivers and river reaches. The upper Meghna is more or less stable, while the lower Meghna experienced extensive and extreme erosion during 1984-93, particularly on the right bank. Sustained annual erosion rates of 100 meters or more over a 10-year period are notable, and occurred on both the lower Meghna and Padma, where satellite image analysis in the inventory reports reveals major changes in the river courses in this period.

Differences in left and right bank erosion rates mean that the Jamuna, and to a lesser extent the Padma and Meghna, are migrating. Analysis of historic maps and satellite images shows that the Jamuna's centerline has moved an average of 4.3 km west since 1830, with a maximum westward movement of 13 km at its northern end. Analysis of a series of images from 1973-92 shows that this river is migrating westward at an average rate of 50 m per year.

The centerlines of all the rivers are moving, but all except the upper Meghna have also been widening. The Ganges has widened relatively slowly, but the Brahmaputra-Jamuna has widened over a 19-year period at well over 100 m a year averaged over its length. Given that this river course is more braided and older than the Padma, which carries the same flow, over time the same widening may occur.

The effects of bankline erosion and widening of the river channel have been great. Analysis of population data, combined with the satellite image analysis, indicates that during the period 1981-92/93 an average of almost 64,000 people were displaced by bank erosion every year, or 728,000 people over the whole period. More than half the displacement was along the Jamuna.

This ignores changes in the chars within the changing banklines. Char erosion and accretion results in more people being displaced, and in the Brahmaputra-Jamuna it was found that 90 percent of the within-bank area had changed between char and water at least once during 1973-92. Therefore, a majority of char inhabitants are likely to have moved.

The growth of within-bank char areas means that some erosion victims can find a living in the chars. The study estimated the population that was displaced by erosion, but that could not have been accommodated in the charlands and instead shifted either to the charland fringe (sheltering on embankments) or left the charlands completely. According to these estimates, 187,000 people permanently left the Jamuna charlands, 19,000-44,000 left the Ganges, 123,000 departed the Padma, and about 120,000 left the Meghna. Hence, an estimated 462,000 people were displaced over an 11-year period, or 12 percent of the 1981 charland population.

The island and attached chars offer some advantages over mainland areas. Availability of cultivable land is higher than the national average, whereas some unprotected mainland supports more people relative to the land resource than does Bangladesh as a whole. Cropping intensity reported in the inventory does not appear to be lower in the charlands than for Bangladesh as a whole, yet the island and attached chars appear to be less productive than mainland areas. In part this reflects soil conditions; but the uncertainties of erosion, frequent flood damage, and control of land by large landowners may all be more important factors. Irrigated crops are scarce in many of the char areas, except for the Meghna, yet river water and groundwater are abundant. Given the uncertainties of the monsoon, the focus of agricultural development should be on the dry season—on high-value crops that can be harvested before the first flood peaks, for example.

A majority of char houses are completely *kutcha*, and very often have walls and thatch roofs made from the catkin grasses that are an important component of the charland environment and resource base. By comparison, on unprotected

mainland 60-70 percent of houses have some corrugated iron in their construction. Charland housing, therefore, is less substantial, but is derived from local materials and is less costly to replace following flood damage or erosion.

Boat transport is critical to trade and to survival in times of erosion or flood in the charlands. Mechanized boats have become widespread in Bangladesh in the past decade. The study found that there are more mechanized boats in the chars than in mainland areas, as might be expected, but it also indicates that there are relatively fewer boats in the Brahmaputra-Jamuna compared with the population. This implies a potential problem along this river for evacuation during extreme floods, and it may limit access to markets and the ability of charland people to sell produce in the mainland.

Given the extensive areas of grassland in the chars and the risk of erosion and flood, cattle are an ideal asset and business since they can be moved to safety (unlike land) and can be sold in times of need. While the RRAs found that in some char areas cattle fattening during the winter and premonsoon is important (in the upper Meghna, for example, which has a combination of grazing, crop residues, and access to markets), cattle ownership per household is lower than the national average. There would appear, therefore, to be opportunities to expand cattle raising in the charlands.

Service provisions are generally poor in the chars compared with mainland areas. This partly reflects difficulties of access, but also a peripheral position with respect to local administrative centers. There has been an emphasis in development work on building infrastructure, such as roads, that is clearly inappropriate in the chars, but alternative investments to improve life in the chars have neither been found nor implemented.

The social and economic lives of char dwellers are in large part determined by the ever-changing nature of the lands upon which they live. Erosion and accretion, migration forced by changing circumstances, and perpetually difficult communication with the mainland effect the structure of char societies and the livelihoods of their people. While the charlands are not easily protected from the impact of flooding, their circumstances can be measurably worsened by disregarding them in flood protection planning.

This study demonstrates that charlands are not all alike. Once they emerge, chars change; and human populations make use of them in differing ways as they develop. One progression takes a char from sand deposition to siltation, and then to some kind of vegetation (usually grasses), followed after a period of years by cultivation and, eventually, human settlement. Given the vagaries of river morphology, the process can be aborted at any point, and the prospects of change in a given char is a major topic of conversation in afternoon gatherings of char men or women.

Typical patterns of physical development and human land use differ from one reach to another and among the four rivers surveyed by the inventory. In the Brahmaputra-Jamuna the majority of chars (56 percent) are settled and cultivated at the same time, although many (39 percent) are cultivated for some time before being settled. In this river the intervals between formation and subsequent developments—natural vegetation, cultivation, and settlement—are on average shorter than in the Meghna or Padma; but there are important differences between sections of each river. Once a char is formed in the Upper Meghna, for example, it seems to take twice as long for vegetation to appear than in other areas of the same river or in the Brahmaputra-Jamuna. The rates of development in the Ganges are different from those of the other rivers, in that natural vegetation appears on average more slowly (after 1.9 years). Cultivation, on the other hand is subsequently initiated more rapidly, in less than two years.

In the upper and middle reaches of the Brahmaputra-Jamuna it takes nearly three years for cultivation to begin after natural vegetation has appeared, but in the lower reach of the same river

the average is closer to two years, as it is in the Padma. Cultivation is initiated more quickly (about two years after the appearance of natural vegetation) in Meghna confluence chars than in those of either the upper or lower reaches (3.5 and 2.6 years, respectively) of the same river.

Jamuna chars are settled nearly two years sooner after the beginning of cultivation than are Meghna chars (after 1.6 years and 3.5 years, respectively). In the Padma there was an average interval of 2.5 years between cultivation and subsequent settlement; but in the upper reach it was 3.5 years. The average interval in the Ganges is 2.2 years, but in the upper reach it is nearly 3 years.

In the Meghna and Ganges, simultaneous settlement and cultivation is not especially common (10-11 percent), and a large majority (more than three quarters) are cultivated before being settled. The Ganges middle reach has more char mauzas settled without cultivation (40 percent) than any other surveyed area. Approximately two-thirds (67 percent) of Padma chars are cultivated before being settled, but 30 percent are settled and cultivated simultaneously.

The Meghna-Padma confluence is similar to the Padma and differs from the upper and lower reaches of the Meghna in that 20 percent of mauzas were found to have been settled and cultivated simultaneously. Cultivation before settlement, however, is still the dominant sequence (74 of 102 cases, or 73 percent).

Very few settlements in any river were established before the onset of cultivation (5 percent in Brahmaputra-Jamuna; 6 percent in the Meghna; 3 percent in the Padma; and 16 percent in the Ganges). If this does occur, however, it takes about three years for cultivation to be initiated in both the Brahmaputra-Jamuna and the Meghna. This is as much as one year longer than it takes to move from cultivation to settlement. Given that people may settle on charland under various arrangements that limit their rights to use the land, or that some people may be forced to live on land that is not yet cultivable, the time taken for a settlement to invest in cultivation is not surprising.

4. Recommendations

The recommendations presented in this report are of five types: information resource development, flood and erosion assistance, basic services, development issues, and policy improvements.

Information Resource Development

The baseline data compiled in the Charland Study inventories needs to be updated periodically, combined with 1991 census data, and refined as development agencies and departments make use of the data for planning purposes. Using the inventory, strategies need to be developed that better utilize the resources available in the chars.

Flood and Erosion Assistance

The study found that people living in chars have developed strategies for coping with flooding and erosion to the best of their limited abilities. To help them in these efforts the report recommends:

- Improved flood warning
- Provision of shelter for people and their animals
- Transportation assistance
- Water purification
- Resettlement services for those displaced by erosion

Basic Services

Char people, by virtue of their changing circumstances and relative isolation, have particular need for assistance with basic services. The report makes recommendations in the following areas:

- Agricultural extension services
- Health and sanitation services
- Schools
- Institutional credit

Development Issues

Policies and procedures that assume a stable land mass and settled populations need to be modified to accommodate the typically changeable charland situations in most river reaches. For example, infrastructure creation (such as road building) must be viewed quite differently for charlands than for mainland areas.

Conflicts between chars can often be traced back to confusions over administrative boundaries. Such lack of administrative clarity also leaves many of chars without public services. The inventory reports highlight many of these problems. Accurate surveys would help efficient administration.

Local government agencies can play an important role in keeping updated inventories of charlands for their respective areas. Such a role also would be useful in making damage assessments following floods and erosion, as well as in developing rehabilitation and resettlement strategies.

Existing social groups (kin groups, neighborhoods, and societies) should form the core of program development to the extent possible, as these groups tend to be interdependent and/or remain together when moving. If leadership is not exploitative, local leaders with the respect of char residents can help to promote innovative ideas and analyze program plans.

Participatory program development (planning done in close consultation with beneficiary groups) is likely to yield the best results in the chars, because it can minimize the chances of setting up unworkable charland programs. Alternative types of earthwork, such as raising flood shelter mounds for cattle and people, are needed in charlands and could be accommodated within existing programs.

Policy Improvements

Major improvements are required in policies relating to land law and the utilization of land. There is a great deal of confusion about the land laws pertaining to alluvion and diluvion, and the existing laws are subverted by a variety of means to the benefit of the local elite. The inventory and RRA surveys found that although vast amounts of land in the chars are technically government-owned *khas* land, such land is mostly under the unauthorized control of locally influential people. In fact, in many chars, the question of land access more often involves "control of land" than "ownership of land". The report makes recommendations about the ways laws may be improved to achieve greater equity in the ownership and use of land in the chars.

Chapter 1

INTRODUCTION

1.1 Background

The original design of the Flood Action Plan (World Bank, 1989) included among its components a socioeconomic study of the active floodplains of the Brahmaputra-Jamuna, Ganges, Padma, and Meghna rivers. The active floodplain was defined at that time as areas within the main river channels and nearby areas of mainland, both of which are frequently subject to erosion and accretion and cannot be protected from floods. The aims of the active floodplain study were to:

- assess present agricultural practices, settlement patterns, and disaster responses;
- estimate the number of affected households on chars (mid-channel islands created by accretion) and within a short distance of the river banks;
- estimate the number of households on existing embankments; and
- prepare guidelines to be used in feasibility studies to ensure that in project planning full account is taken of the active floodplain populations.

As the detailed terms of reference (TOR) of FAP 14, the Flood Response Study, were being drawn up by the government of Bangladesh and finalized with donor agencies, it became apparent that the intended study would not immediately be possible. A more general study first was needed to establish—for the full range of flood environments inside and outside the chars—the context in which flood response occurred. In addition, the active floodplain study required the use of remote sensing data and satellite image interpretation, but the facilities and trained staff to achieve this within the FAP would not be ready until at least late 1991.

During 1991, the first full year of FAP studies, it became clear that regional studies were unable to devote sufficient resources to the specialized work of socioeconomic study of the active floodplain. Most used the main rivers as their study area boundaries. Of the regional FAP studies only FAP 3.1, the Jamalpur Priority Project, attempted detailed socioeconomic studies in the chars, investigating those along the reach of the Jamuna adjacent to the project in 1992. FAP 14, the Flood Response Study, later undertook detailed household surveys in 10 active floodplain villages.

Finally, in 1992 ISPAN, on advice from the Flood Plan Coordination Organization (FPCO), agreed to undertake an inventory of resources and people in the main river charlands. This study, then, fulfills the need—foreseen in the Government of Bangladesh/World Bank Flood Action Plan of 1989—for a socioeconomic study of the people and resources of the active floodplain. Although it does not consider in detail the populations living long-term on embankments along the main rivers, analysis of erosion and accretion patterns has been added.

The inhabitants of the charlands are among the most hazard-prone people of Bangladesh, exposed as they are to floods and erosion. Structural flood protection measures are unlikely to benefit these people, and embankments may even raise flood levels within the charlands, increasing the risks to which they are exposed. Reliable information about these areas and the people who live in them has always been scarce. The difficulty of gaining

access to chars and their constantly changing environment has made studying them a complicated undertaking. As a result, prior to this study, what little information was available did not cover in any detail all the main river charlands.

1.2 The Charland Study

This Charland Study is a special study under the Bangladesh Flood Action Plan (FAP). It was executed jointly by FAP 16, the Environmental Study, and FAP 19, the Geographic Information System (GIS), both of which are undertaken by the Irrigation Support Project for Asia and the Near East (ISPAN) and funded by USAID.

This study has two objectives. The first is to develop databases and a geographic information system (GIS) that can be used as planning tools both for direct interventions in the charlands and for other interventions (such as embankments) that may affect the char areas. The second objective is to use the data collected, along with additional socioeconomic studies, to make general policy recommendations for the charlands and to test and develop means of rationally identifying potential flood proofing measures and assessing their potential benefits in these areas.

Five tasks have addressed these objectives.

- Making an inventory of resources, people, and infrastructures in the Brahmaputra-Jamuna, Meghna, Padma, and Ganges charlands and collecting additional information on hazards (led by FAP 16).
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This document summarizes the overall findings of the study, concentrating on the inventory results and a comparison of the charlands of the four rivers studied. Information from the Socioeconomic Study Summary Report, the Socioeconomic Study rapid rural appraisals, and the flood proofing surveys is summarized where appropriate. This report includes recommendations and guidelines based on all the Charland Study components.

The study's primary product is a database derived from the field inventory returns that, when combined with data derived from Landsat imagery, forms an interactive GIS. Much of the data gathered has been mapped and reported in detail in the four individual river inventory reports.

1.3 The Study Area

Figure 1.1 shows the extent of the riverine charlands covered by this study. The study extended from the border with India along both the Ganges and Brahmaputra, through the Padma and Lower Meghna as far as the southern edge of Hizla Thana and northern corner of Lakshmipur Thana. This boundary was selected for the study because the Lower Meghna becomes increasingly estuarine here, this point is also the approximate boundary of the cyclone prone zone which was studied under the Multi-purpose Cyclone Shelter Project.

The Upper Meghna was included as far as the first reach with a narrow single channel in Araihazar Thana south of Narsinghdi. The river downstream of this point has typical island chars as well as large areas of old established mainland that are detached from other mainland by channels of the Meghna and for which no flood protection is planned. There are other areas of riverine charland in Bangladesh, along the Teesta and Old Brahmaputra, for example, but these charlands are relatively small and are located within the confines of FAP regional studies. The areas covered by this

Figure 1.1 Charland Study Location

bird-4-c.gem

study by and large adjoin the planning areas of the FAP regional studies, and this study therefore complements other components of FAP.

The divisions between the rivers are mostly at the confluences. The one exception is the Padma-Meghna confluence, where the flow of the Padma is turned 90 degrees and there is a complex and dynamic system of chars, this was included in the Meghna study area.

1.4 The Charlands, a Definition

This study is primarily concerned with riverine charland, the Bengali term for a "mid-channel island that periodically emerges from the riverbed as a result of accretion" (Elahi *et al.*, 1991), and more generally with the active floodplain, which is subject to erosion and accretion. Additionally, some mainland adjoining the main rivers, while not chars in the above sense, is also at risk from bank erosion and is just as flood-prone as the chars. These areas were included in the study.

Land and mauzas in the study areas were classified into the following three main types (subdivided by left and right bank as appropriate):

- Island chars.
- Right and left bank attached charland.
- Right and left bank unprotected mainland.

Figure 1.2 illustrates this classification system, which was developed for the charland inventory.

For this classification, island chars are defined as land that, even in dry season, can only be reached by crossing a main river channel. Attached charland is accessible from the mainland without crossing a main channel during the dry season (crossing lesser channels may be required), yet is inundated or surrounded by water during the peak of a "normal" flood (normal monsoon). Setback land is mainland on the river side of flood protection embankments. It differs from other unprotected mainland because the embankments may provide refuge during floods but may also constrain flood water, thereby raising flood levels. Unprotected mainland has no embankment between it and the main river and is inundated during higher than normal floods. Unprotected mainland has been surveyed up to the extent of recent floods or features, such as roads, that restrict flooding.

1.5 Methodology

1.5.1 Inventory

The study incorporates data generated from digital satellite imagery and field data (questionnaires) collected at the mauza level. These have been integrated using a database and GIS, which disp-

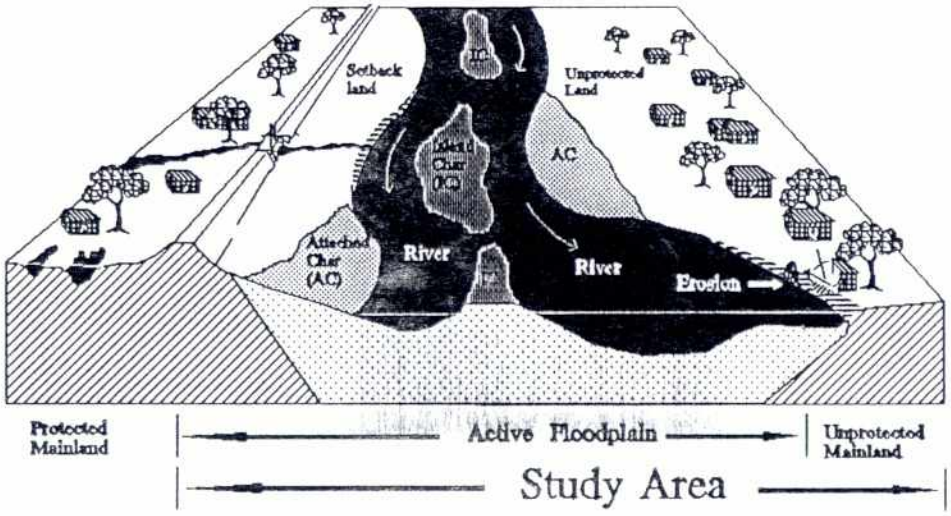


Figure 1.2 Charland Classification

lays the field data as digital maps. The methodology for the mapping and field surveys evolved during the Brahmaputra-Jamuna Charland Study, which was undertaken in 1992. The final inventory methodology used an iterative process of refinement using maps, images, fieldwork, and questionnaire data; generally the sequence was as follows:

- defining the study area;
- digitizing mauza boundaries;
- correcting maps and images to common coordinates;
- combining and reconciling mauza and study area boundaries with the 1993 dry season Landsat image;
- designing the questionnaire;
- producing prints of the satellite image overlaid with mauza boundaries and mauza lists for field use;
- conducting the inventory questionnaire survey;
- entering and verifying data;
- adjusting the GIS database with revisions to study area boundaries and additional information from field teams; and
- tabulating, analyzing, and mapping data.

The main problems encountered in the inventory were related to uncertainties over the locations and boundaries of mauzas, the basic units of the survey. For example, there are mauzas not shown in the Police Station maps or in the BBS Small Area Atlases (which formed the basis for the mauza extents used in mapping inventory data), although listed in the latter. Other mauzas and areas of charland, although inhabited, were not included in any secondary sources. By consulting the local administration and people the inventory field teams made corrections to the mauza mapping and filled in such gaps, so that the inventory is as comprehensive as possible.

1.5.2 Supplementary Charland Studies

In addition to the inventory, more qualitative information was obtained from a small number of mauzas in selected reaches of the rivers using rapid rural appraisals (RRAs). This part of the study involved selecting mauzas that could represent typical conditions in each land type within a study reach, and it included locations that were interlinked, for example, through circuits of population movement in response to erosion events or through economic connections. This part of the study aimed to give insights into critical economic and social factors and processes underlying the aggregate patterns documented by the inventory.

These studies indicate many types of interventions that could help to improve the lives of char people and reduce their vulnerability to flood and erosion hazards. The charlands by definition are areas not presently protected from floods and unsuited to embankment protection. In terms of frequency and severity of flood impacts, they are among the most flood-prone parts of Bangladesh, and this situation may worsen if flood protection embankments confine peak floods to the charlands.

Flood proofing measures (small-scale structural and non-structural measures to reduce individual and community losses) are a direct means of counteracting these problems. The flood loss and flood proofing survey was designed to provide the data necessary to design appropriate flood proofing measures, concentrating on household non-agricultural losses. Household sample surveys done as part of that study estimate flood losses in 1988 and 1991 for two reaches of the Brahmaputra-Jamuna, and identify those components of overall losses that might be prevented by raising houses, constucting flood shelters, and improving flood warnings. The sample locations are in what have been, in recent years, the most flood-prone parts of the Jamuna River. They include the area where FAP 25 predicted the greatest increase in peak flood level due to proposed embankments and construction of the Jamuna Bridge.

1.5.3 Satellite Image Interpretation

The Landsat imagery analysis on char physiography was carried out for the Ganges, Padma, and Meghna by superimposing on the most recent dry season image (1992 or 1993) an image from the 1984 dry season. The same procedure was fol-

lowed for the Jamuna, but a series of seven earlier images from 1973 through to 1987 were used. The image analysis enabled the following to be mapped and quantified:

- Char persistence;
- Erosion and accretion patterns over time; and
- Current land use and cover.

Mauzas were categorized according to the charland types defined in Section 1.3. For each mauza, the proportions of mauza area in each category were determined based on field observation, local information, and the 1992 or 1993 satellite image, as appropriate.

1.6 Literature Review

Most writing about chars emphasizes either the fertility of their lands, the violence of their people, the quasi-utopian coherence of their communities, or their lowly and neglected status in the national planning framework.

The fertility of chars has long been recognized. In the mid-17th century, Francis Bernier described the deltaic islands as very fertile but uninhabited because of the danger of pirate attacks (Nicholas 1962:65-66). Rennell mentioned that floods contribute to the growth of an island, providing "mould enough on it for purposes of cultivation," (1793:347) and described the islands of the Meghna below the (then) junction with the Ganges and Brahmaputra as rivaling "in size and fertility, our Isle of Wight" (1793:358). As Carstairs said, "...A newly formed island, though next season might see it swept away again, might also become a rich estate, of good land." (1895:242-243, quoted in Zaman 1991:553). W.W. Hunter, writing in the late 19th century, described how midstream islands benefit from the silt depositions that coat the country after floods with "a top-dressing of virgin soil, brought free from the Himalayas...a system of natural manuring which defies the utmost power of over-cropping to exhaust its fertility" (Hunter 1894:1-2).

The agricultural value of some of the charlands led to the development of increasingly complicated laws about rights to them from the early 19th century onward. For example, it was necessary early on to develop a special body of law relating to island chars that were submerged at the time of the Permanent Settlement (or Decennial Settlement) of 1793.

Because of their changeable nature and typical remoteness from the mainland, chars always have been treated differently in law, and in many places have been governed informally more than formally. They even were affected by *zamindari* abolition and land reform legislation differently than other parts of the country; and special laws relating to land rights in the chars have not always had their intended effects.

The emergence of chars can occasion conflict as competing parties try to claim them. Numerous scientific and journalistic reports about such situations have given chars a reputation for violence. Zaman and others have made detailed analyses of island char society, especially legal and violent struggles over land rights. Zaman (1989) has compared Brahmaputra-Jamuna char areas around Kazipur to parts of southern Italy and Sicily where the Mafia is the effective local government:

> *"Few people in Bangladesh have heard of cases of poor peasants getting their due shares of land in the newly emerged chars. On the contrary, the use of violence, dispossession, murder, rape and confiscation of crops and livestock have become local, and almost established practices of char life. The selective use of violence by local jotedars who act as patrons of the lathiyals [aggressive, stick-wielding bands of muscle-men] work as the ultimate arbitrator of dispute over new char lands."* (Zaman, 1987:8).

Strong internal power relationships are part of the quasi-military situations described above. There are reports of displaced people being forced to serve as *lathiyals* for those who provide them with shelter.[1] Crow and Murshid (1990) described a credit system in one char area that led to debt servitude for many and diminished the capacity of marginal farmers to profit from their crops.[2]

Another group of reports highlights the supposedly strong internal cohesion of char communities and their mutually supportive economic activities, such as sharing of supplies and even living areas as family fortunes shift. The North West Regional Study (FAP 2) draft final report, for example, says that "[Char people]...have individual and collective strength to survive in situations which many would find impossible;" and "...There is a degree of collective endeavor on the chars that is not much in evidence in villages elsewhere." (Bangladesh Flood Action Plan 1992: 2-23). One report, apparently written by an NGO (Service Civil International?, n.d.), argues that people of the Bhuapur area in the lower reach of Brahmaputra-Jamuna know they may need help from others someday, so they take care of each other "simply because they share a common understanding of the river and [its] unpredictability." "Life in the char," as this source describes it, "is difficult, but the social and cultural adaption of this sizeable population, and in a sense, their evolution along with their environment, has created a cultural interchange and a communal spirit that has adapted to the viciousness of the river. The people who inhabit char villages have developed a unique coping mechanism and adaption to their environment. The Jamuna serves as both the common link, as well as, the common nemesis."

Other FAP studies that have looked into socioeconomic aspects of char life in varying degrees are: the Jamalpur Priority Project (FAP 3.1) mentioned above, the Flood Response Study (FAP 14), and the Flood Proofing Study (FAP 23). The Jamalpur Priority Project study (FAP 3.1) gathered information on social and economic characteristics of a sample of households in 63 villages in the Brahmaputra-Jamuna middle reach. A basic concern of the study is the potential of embankment construction to increase the flood risk on chars and setback (unprotected mainland) lands while improving flood protection to the mainland. On a smaller scale, other FAP studies have addressed the characteristics and needs of char populations in specific areas. The Flood Response Study (FAP 14), for example, included five island char settlements in its sample of 30 villages. The Flood Proofing Study (FAP 23) also made some general recommendations for flood proofing programs in chars. All of these have emphasized, to one degree or another, the difficulty of life on island chars, their vulnerability to floods, the great variability in (and common inadequacy of) public services, and the serious economic disruption caused by losses of land and other assets to erosion.

> *Where [a] river was included within the limits of an [zamindari] estate, and chars were thrown up in its bed after the Decennial Settlement, the question was not free from controversy till...1921.*
>
> *...Section 4(1) of [the Bengal Alluvion and Diluvion Regulation XI of 1825] lays down that where the char is an accretion to riparian estate, the proprietor of the estate is entitled to settlement of the accretion as if it were an increment to his tenure; but where the char is an island in the midst of a river and the channel between it and the river is not fordable, it would be at the disposal of the Crown (section 4(3)); that is to say, that Government may settle it with any person they consider proper, or keep it under direct management.* (Gupta, 1940:258-259).

A major piece of related work done outside the Flood Action Plan was the Riverbank Erosion Impact Study (REIS), a joint project of Jahangirnagar University and Manitoba University, which covered three areas affected by erosion—Bhola Island (deltaic), Kazipur (Jamuna), and Chilmari (Brahmaputra). The emphasis of the socioeconomic side of the REIS project was on displacement of populations and concomitant resettlement patterns and needs. In conjunction with this project, some

in-depth analyses were done of social organization and land tenure in specific char and erosion-affected populations of three regions. Having covered the deltaic Bhola area, this was the only comprehensive study to date to go into any depth on land and life in the coastal chars. Important differences were identified between settlement of river islands and deltaic chars. This project emphasized the urgent need to address land tenure issues, such as land-grabbing in newly accreted lands, and has recommended that a national commission be formed for this purpose. The comprehensive study report included several complex suggestions about ways to improve char people's lives. Among its recommendations was a new system of floodplain zoning (Elahi and Rogge 1990; Elahi *et al.* 1991).

Char people have attracted a certain amount of public attention in the local and international media, which tend to represent them as very deprived and needy of social services.

> *"Remote, isolated and inaccessible the world of the Char people is haunted by unemployment, malnutrition, superstition and above all uncertainty. Public facilities such as markets, clinics or schools are few and far between, even the hand of government extends only weakly into these backwaters."* (M. Khan, *Daily Star*, 13 September 1993).

A French film on char life, in which the NGO Service Civil International (SCI) collaborated, was viewed by a large foreign public. This film critically reviewed several development initiatives, including river training works that might have negative consequences for char people, whose life was depicted as very difficult. A 1993 article in *National Geographic* magazine used charlands as an example of how in Bangladesh, "the power of the water to destroy is almost equally matched by its power to create." (Cobb, 1993:120).

The chars and surrounding areas have indeed been the object of concentrated attention by few NGOs and other service providers (including PACT/PRIP). The most comprehensive study associated with such efforts is a baseline study of nutrition and socioeconomic indicators in Chilmari Thana by Bruce Currey. This study involved one review in 1979 and a follow-up project in 1985.

In the northern Jamuna, Rangpur Dinajpur Rural Service (RDRS), an NGO, has set up a large program for 12,000 char families living in 12 areas, who have been organized into small self-help groups. The characterization of char life in a 1993-1997 proposal by this organization reflects some of the same views found in the media (which philanthropic funding agencies are likely to use as their source of information):

> *"Chars are normally very remote and accessible only by country-boats. Unemployment, severe malnutrition, poor health, abandonment of women and superstition are endemic. Public facilities and government services are very sparse. Char land is entirely sandy with little organic matter resulting in poor productivity."* (RDRS, 1992).

NOTES

1. Sharif Kafi, personal communication.

2. The remote area described in this paper was not identified as a char area, but it was one. (Ben Crow, personal communication, August 1993)

Chapter 2

RIVER EVOLUTION, CHAR DEVELOPMENT, AND LAND RIGHTS

2.1 Historic Evolution of the River System

The delta of three rivers, the Brahmaputra, Ganges, and Meghna, has created the land of Bangladesh. The combined flow of these three rivers makes this the third greatest river system in the world. In a 1-in-100 year peak flood the combined flow of these rivers is more than six times that of the Mississippi (Coleman, 1969). The rivers drain a total catchment of 1.7 million km^2, which includes the most tectonically active mountains in the world, the Himalayas, as well as the highest rainfall area in the world. The Brahmaputra and Ganges carry a vast sediment load, estimated at up to one billion m^3 per year (FAP 4, 1993), and are in a constant state of adjustment and change in response to seasonal variations in their flow and sediment loads. Within the past 200 years or so the river system of what is now Bangladesh has undergone several dramatic changes.

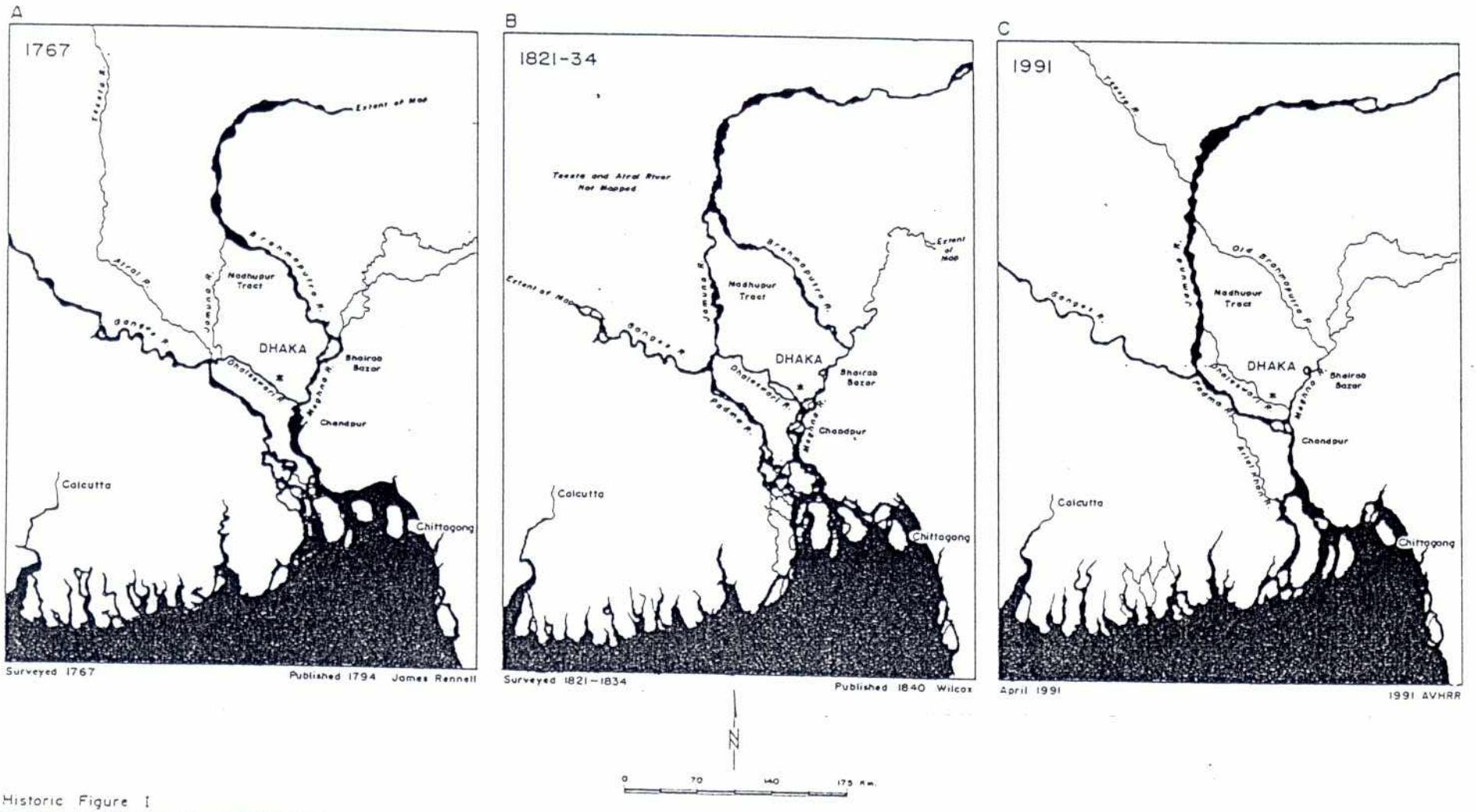
Map A in Historic Figure I shows the lower Ganges-Brahmaputra river system in about 1770. The Brahmaputra curved east through Bengal and joined the Upper Meghna northeast of Dhaka, while the Ganges travelled a separate course to reach the Bay of Bengal west of the Meghna mouth. A major change in the Brahmaputra course occurred between 1780 and 1830, and Map B shows that in the 1830s, while the old Brahmaputra course was still important, much of that river's flow went due south in the new Jamuna River to join the Ganges. The combined flow then joined the Lower Meghna in a wide delta some 65 km south of the present confluence (Rizvi, 1975). Between the 1830s and 1857-60, the Padma broke through more resistant Chandina Alluvium to join the Meghna near its present confluence. Since then the river system has been adjusting to these major changes. Map C shows the late-20th-century river system: the Old Brahmaputra is reduced to a flood spillway, and the combined Ganges-Jamuna flow passes through the Padma to join the Meghna just north of Chandpur.

The Ganges, too, has been a major contributor to the delta building process that has created the land of Bangladesh. While the size of the catchment outside Bangladesh has changed little in historic times, the course within what is now Bangladesh has gradually changed, as the active part of the Ganges delta has migrated eastward.

At one time the Ganges main channel was in the area of the present Hoogly in Calcutta, but in the 15th or 16th century the river swung eastward to follow a course close to that of the present day Gorai. By the mid-18th century the river had migrated further east and entered the sea close to the present Arial Khan. The basic route of the Ganges course is unchanged since then.

In the past 200 years, then, the main flow of the Brahmaputra moved 60 km west, the Upper Meghna lost much of its flow, a major new river (the Jamuna) was created, a vast river (the Padma) combining the Ganges and Brahmaputra-Jamuna flow was created, and this river then moved eastward to capture the Meghna and form the present Lower Meghna. These changes resulted in the Madhupur Forest Tract being surrounded by rivers, the Dhaleswari flowing southeast from the Jamuna instead of northeast from the Ganges, and the Ganges flow moving progressively eastward.

EVOLUTION OF THE RIVER SYSTEM OF BANGLADESH



Historic Figure 1

ISPAN FAP 19, Geographic Information System

2.2 Stages of Char Development

2.2.1 Physical Changes

Once they emerge, chars change; and human populations make use of them in differing ways as they develop. One progression takes a char from sand deposition to siltation, and then to some kind of vegetation (usually grasses), followed after a period of years by cultivation and, eventually, human settlement. Given the vagaries of river morphology, the process can be aborted at any point, and the prospects of change in a given char is a major topic of conversation in afternoon gatherings of char men or women. Several settlements visited during RRAs were set up on a temporary basis as people waited to see whether their islands would survive that year's erosion.

Typical patterns of physical development and human land use differ from one reach to another and among the four rivers surveyed by the inventory.[1] Figures 2.1 shows the evolution of charland use in the Jamuna, and Figure 2.2 illustrates the evolution of settled charland for each of the rivers.[2]

In the Brahmaputra-Jamuna the majority of chars (56 percent) are settled and cultivated at the same time, although many (39 percent) are cultivated for some time before being settled. In this river the intervals between formation and subsequent developments—natural vegetation, cultivation, and settlement—are on average shorter than in the Meghna or Padma; but there are important differences between sections of each river. Once a char is formed in the Upper Meghna, for example, it seems to take twice as long for vegetation to appear than in other areas of the same river or in the Brahmaputra-Jamuna. The rates of development in the Ganges are different from those of the other rivers, in that natural vegetation appears on average more slowly (after 1.9 years). Cultivation, on the other hand is subsequently initiated more rapidly, in less than two years.

In the upper and middle reaches of the Brahmaputra-Jamuna it takes nearly three years for cultivation to begin after natural vegetation has appeared, but in the lower reach of the same river the average is closer to two years, as it is in the Padma. Cultivation is initiated more quickly (about two years after the appearance of natural vegetation) in Meghna confluence chars than in those of either the upper or lower reaches (3.5 and 2.6 years, respectively) of the same river.

Jamuna chars are settled nearly two years sooner after the beginning of cultivation than are Meghna chars (after 1.6 years and 3.5 years, respectively). In the Padma there was an average interval of 2.5 years between cultivation and subsequent settlement; but in the upper reach it was 3.5 years. The average interval in the Ganges is 2.2 years, but in the upper reach it is nearly 3 years.

In the Meghna and Ganges, simultaneous settlement and cultivation is not especially common (10-11 percent), and a large majority (more than three quarters) are cultivated before being settled. The Ganges middle reach has more char mauzas settled without cultivation (40 percent) than any other surveyed area. Approximately two-thirds (67 percent) of Padma chars are cultivated before being settled, but 30 percent are settled and cultivated simultaneously.

The Meghna-Padma confluence is similar to the Padma and differs from the upper and lower reaches of the Meghna in that 20 percent of mauzas were found to have been settled and cultivated simultaneously. Cultivation before settlement, however, is still the dominant sequence (74 of 102 cases, or 73 percent).

Very few settlements in any river were established before the onset of cultivation (5 percent in Brahmaputra-Jamuna; 6 percent in the Meghna; 3 percent in the Padma; and 16 percent in the Ganges). If this does occur, however, it takes about three years for cultivation to be initiated in both the Brahmaputra-Jamuna and the Meghna. This is as much as one year longer than it takes to move from cultivation to settlement. Given that people may settle on charland under various arrangements that limit their rights to use the land,

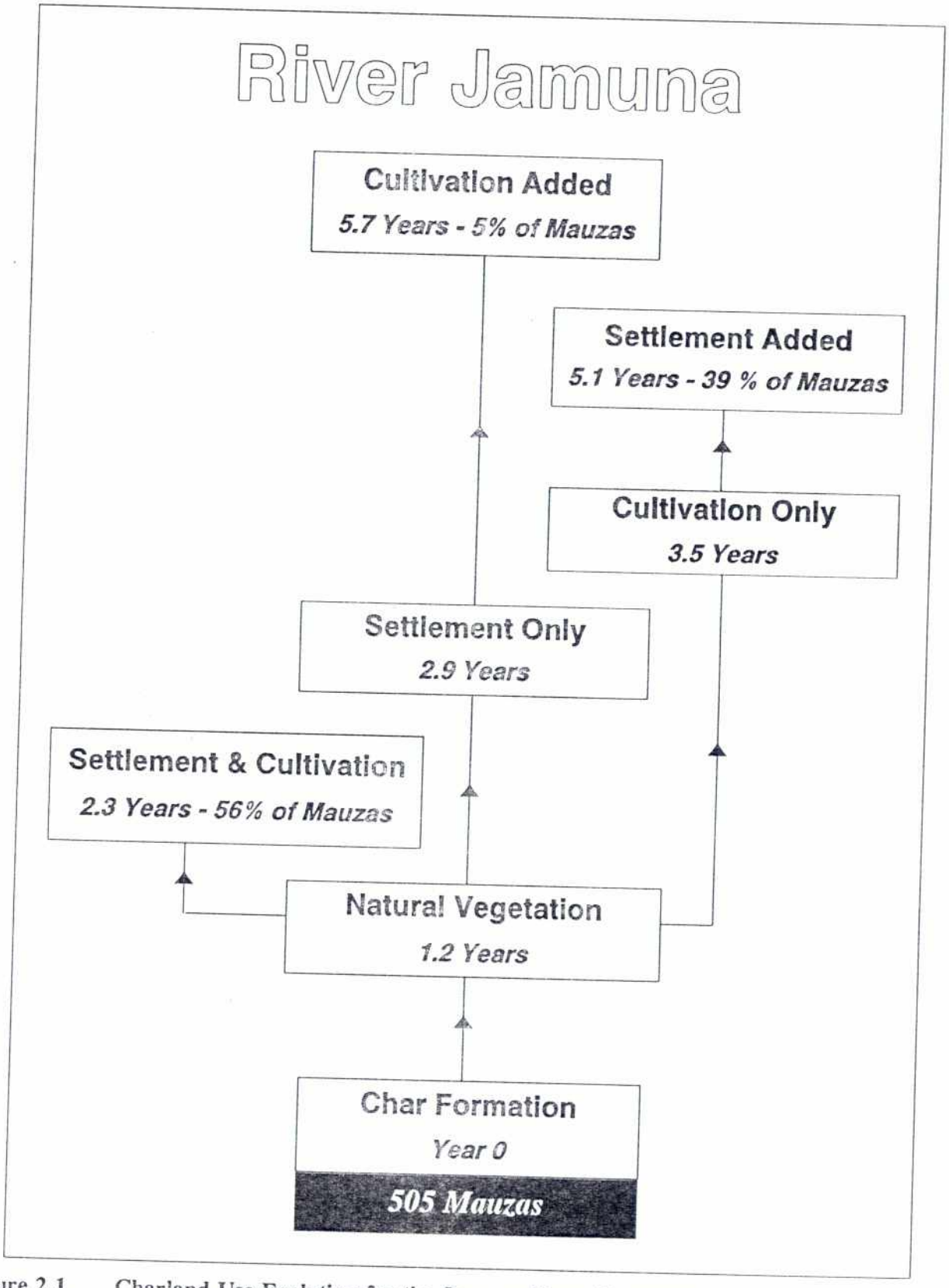
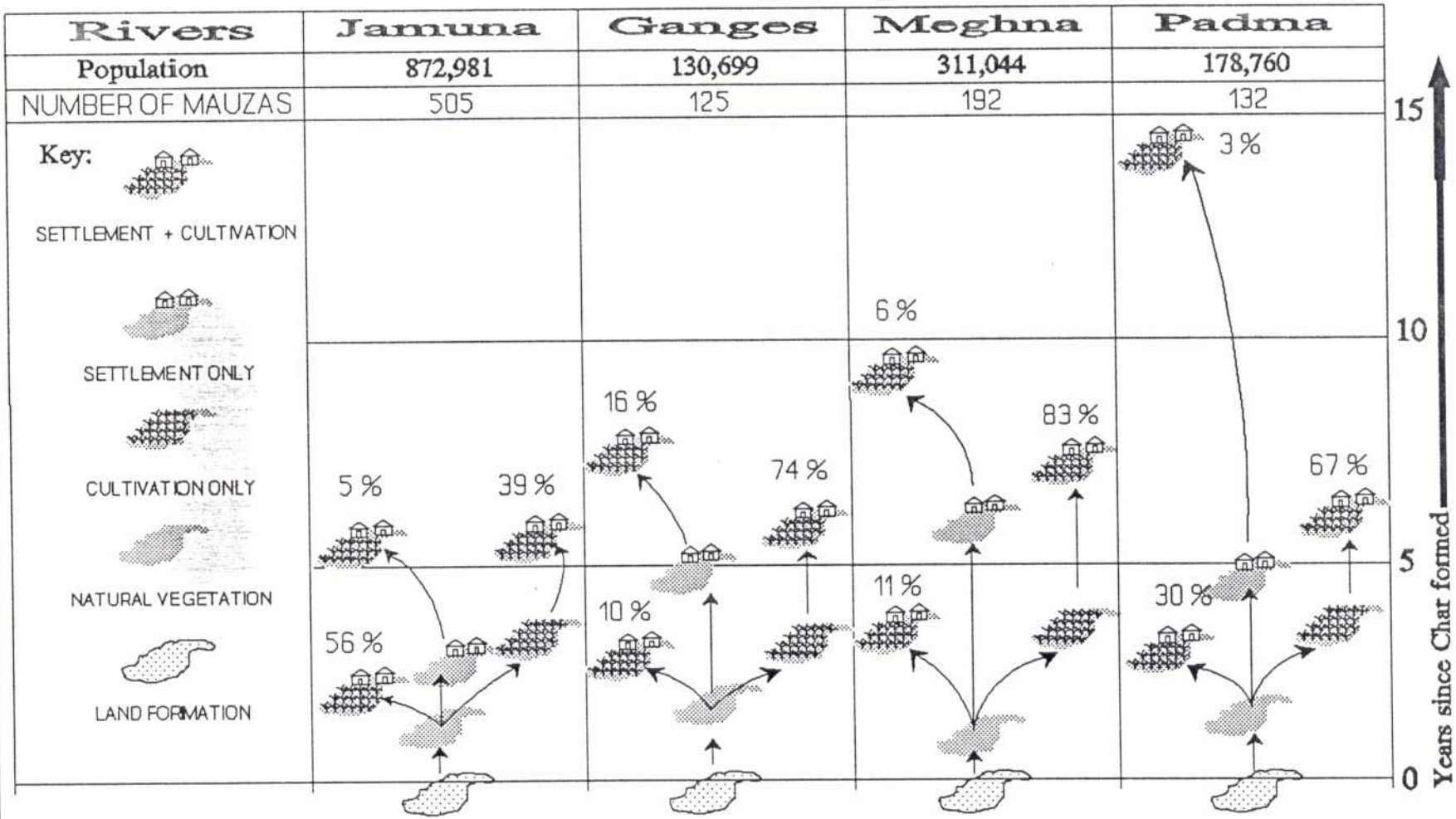


Figure 2.1 Charland Use Evolution for the Jamuna River (Averages)

Figure 2.2 Evolution of Settled Charland in the Major Rivers



Percentage given is for those mauzas where the sequence was recorded.

or that some people may be forced to live on land that is not yet cultivable, the time taken for a settlement to invest in cultivation is not surprising.

2.2.2 Bengali Terms for Char Development

Char people, depending as they do on the shifting lands, have a special vocabulary for the all-important changes in their environment. This vocabulary is not the same in all places, but the RRA team gathered some information on it, which helps to understand how char people see their world. In the Padma River a newly emerged char is called "floating river land" (*nodi bhasha char*), while a char that has existed for 10 to 20 years is called "ancient" (*shabuk* in the local dialect). In the lower Brahmaputra-Jamuna, people distinguish between a *char*, which emerges in the Bengali month of *Ashwin* (September-October) near the end of the monsoon season, and a *doba char*, which emerges later. In time, they explained, if it does not erode, it will become a "stable, established" (*kayemi*) place suitable for human settlement. The old words *diara, char,* and *rehai* are used interchangeably in the Padma to refer to islands, although *char* is the one currently in vogue.

Every region has some words for the mainland. Common ones are: *kayemi* in the northern part of Brahmaputra-Jamuna (literally, "stable"), *bir* in the middle reach of Brahmaputra-Jamuna (around Jamalpur),[3] and *desh* (literally, "state") or *denga* (literally, "lands near a river") in the Ganges.

2.2.3 Histories of Human Settlements

Chars have come to be settled in a number of different ways; and the RRA team encountered many situations of people in transition of one sort or another. In every area there was a core group who said they had been there for several generations, or as long as anyone could remember. Others had more specific migration histories. In the upper and lower reaches of the Brahmaputra-Jamuna many people settled on chars as renters or sub-tenants of large landlords (*zamindars* or *jotedars*) within the past century. In the Ganges, three of the six settlements visited had populations that had been recruited recently by large landlords seeking to claim, clear, and cultivate new chars. In the Ganges and Padma RRA studies these landlords were still referred to as *zamindars*. Many settlers in each area move from place to place within the rivers in small groups seeking sanctuary with relatives or acquaintances when their lands disappear. Some chars have been settled from the mainland or other chars by people taking advantage of government land distribution or "cluster village" programs.[4] Some influential men of certain char regions own land in several places and move together with a retinue of dependents from place to place as their lands come and go, while others deploy forces of sharecroppers on their charlands but remain on the mainland as absentee landlords, a common pattern in the middle Padma and a pattern occasionally found in the Brahmaputra-Jamuna and Ganges as well.

In some areas, social distinctions based on migration history persist. In the northern reach of the Brahmaputra-Jamuna, for example, one group calling themselves *Bangalis* sees themselves as the original settlers in their chars and maintains slightly different customs and some social distance from another group, the *Bhatiyas*, whose predecessors came mainly from Pabna District and Mymensingh (including Tangail) around the turn of the century. A similar situation was found in the Ganges, although in this case some of the original settlers called themselves either *Chauras* or *Deshis*, and the "newcomers" are called *Bangalis*.[5] The grandparents of the latter group came from Dhaka, Manikganj, and Noakhali seeking agricultural land and work opportunities in charlands.

2.3 Land Rights

Against the backdrop of the dynamic erosion and accretion of charland, the question of land rights assumes particular significance. Successive surveys conducted by the government have not been done in a way that dispels the confusion about the sub-

ject; rather, these have often added to the confusion by not trying to properly build one upon the other.

Land in the chars can be owned either by individuals or by the government; in the latter case it is known as *khas* land. In what follows, the subject of land rights is first discussed with respect to privately owned land, followed by a discussion of *khas* land.

2.3.1 Privately Owned Land

The controversy over who owns how much of newly accreting land on chars does not become acute as long as the land in question was previously recorded as belonging to a particular person, and the process of accretion takes place in quick succession to the event of erosion. When land is expected to accrete relatively soon after erosion (as has been the case in the Meghna confluence, where the average interval between erosion and accretion is three years and the average time between accretion and settlement is three years; see Table 2.1), the erosion-affected people prefer and mostly manage to stay nearby where they can monitor the status of their land. Once the land surfaces, it is common practice to re-demarcate their land using private *amins* (land surveyors) to make fresh measurements. If there are some small controversies, the *matbars* (leaders of local communities) usually resolve them. Major disputes may end in violent conflicts and formal litigation, however. Such disputes are more frequent in areas where land remains submerged for a long time after erosion, so that ownership rights become blurred.

The current law on land ownership in the context of erosion and accretion states that when the land belonging to an individual is eroded and later resurfaces, the newly emerged land becomes the property of the government. In practice, people whose land is eroded resort to various means to prevent such an eventuality. There are some who continue to pay taxes on the eroded land to avoid official attention to, and subsequent recording of, the fact that the land in question has actually been eroded. Others manage to divert attention by exerting their influence. When the land resurfaces, these people arrange to pay backdated taxes, so that the erosion phase of the land does not get officially recorded. Powerful people use similar means to obtain new land, paying back taxes on the land of people who have left the area.

An average *tahsil* (land record/revenue) office has very little in the way of personnel or resources (e.g., vehicles and boats) to cover the geographical area under its jurisdiction, and it would be naive to expect that these laws could be implemented by them. The government cannot expect to collect all

Table 2.1 Examples of Erosion-Accretion-Settlement Timing for Meghna Confluence Island Chars

Mauza	Erosion Year	Accretion Year	Settlement Year
Adam Manirabad	1988	1990	1993
Char Allen	1987	1989	1991
Dakhsin Borochar	1975	1980	1983
Chirar Char	1974	1978	1981
Nasirarkandi	1988	Still Eroding	People Migrating Away
Shibsen	1987	1990	1993

Source: Charland RRA

land taxes when the land in question is eroded and submerged. Apart from a few people who lost small pieces of land and are interested in government loans requiring that all land taxes be paid up, most erosion victims in the RRA study areas very seldom pay taxes on eroded land. The char people also feel that tax rates for the mainland and chars should be different since their land tends to be less productive and the risk of losing crops is much higher than in the mainland. As a result, collection of land taxes is extremely poor (one *tahsil* office reported that the "good" areas would pay up to 20 percent of the assessed amount).

2.3.2 Land Rights Laws: Alluvion and Diluvion

The laws on land rights for chars subjected to erosion and accretion have the following historical milestones:

- Permanent Settlement, 1793—established proprietary rights of *zamindars*
- Bengal Alluvion and Diluvion Regulation (XI of 1825)
- The Bengal Alluvion Act, 1868
- State Acquisition and Tenancy Act, 1950—abolished proprietary rights of *zamindars* and (Sections 86, 87) modified charland rights of others
- Ordinance LXI of 1975 (effective from 4 November 1972)

Of these legal documents, the last two are most relevant to present-day understanding of the subject. While the Act of 1950 allowed the repossession of accreted land by the previous owners if the accretion occurred within 20 years of its erosion, the Ordinance of 1975, an Amendment to the Act of 1950 brought about by a Presidential Order (No. 135) in 1972, provides that "all newly emergent lands previously lost by diluvion should be restored not to the original owner but only to the government". Recently there have been moves to revert to the 1950 procedure.

The people of the chars find it very hard to accept a law that says that their land would not be turned back to them if and when it resurfaces. While the purpose of the law might have been to "recover" land from the powerful *jotedars* and redistribute it among the landless and marginal farmers, in reality such redistribution is rare. Instead, "redistribution" in the opposite direction is more common. Powerful people are able to use whichever land legislation is to their advantage to retain land or add to their holdings. They may, for instance, draw the erosion of other people's land to the attention of the land administration hoping that the land will be declared *khas* when it resurfaces, so they can then lease it and obtain control over it.

2.3.3 Government-Owned (*Khas*) Land

A large proportion of charlands in some areas, particularly in the Ganges, is *khas* land. Rights over the use of *khas* land often bring about controversies and conflicts.

The rules and regulations on how to put *khas* land to use specify taking a lease from the local land revenue (*tahsil*) office; such leasing is commonly known as obtaining a "DCR," (Duplicate Carbon Receipt). In reality, considerable *khas* land seems to be forcibly occupied by locally influential people. It is common practice for such people to lease a small amount of *khas* land from the government, and then spill over their domain of control (and use) into much wider territories of *khas* land.

Many char areas, particularly in the Ganges and Padma, were under the active control of *zamindars* from the time of British rule. When the *zamindari* system was abolished by the East Pakistan State Acquisition and Tenancy Act of 1950, much of the land there was converted to *khas* land. A few households in these areas still claim very large landholdings (well above the currently allowed ceiling) because their forefathers had big landholdings (mostly obtained as revenue collection estates under the *zamindari* system). Since the law does not permit such large holdings, these people are said not to have proper documents to claim such ownership. Typically, people keep land in the

names of their relatives to get around the constraint of the land ceiling. Because they do not have proper official documents to claim ownership of all that land, these large landowners are not in a position to sell off their land to purchase property in the mainland, if they should so desire.

To maintain authority on such land, these influential people try to attract erosion-affected households and other very poor groups to settle on "their" land. One way of doing this is to announce to potential settlers that they can take home all of the first two crops they produce, as these crops will require high investments in labor in clearing natural vegetation and preparing the land. The people controlling the land often do not honor these informal contracts, and at times there have been conflicts between those who control the land now and others who seek to control it, resulting in the real cultivators not being able to get their own harvest.

Influential people who have traditionally had possession of *khas* land often retain the ownership of that land through cycles of erosion and accretion.

In some cases, newly accreting *khas* land is distributed among the people of a mauza/village, the distribution usually being skewed in favor of the local elite. Although the government has a program of leasing out *khas* land to poor landless people, there has been very little evidence of its implementation. Usually influential people, such as *matbars*, large landowners, and union parishad chairmen, arrange applications from eligible candidates but maintain control over the leased land, settling tenants on new chars, for example, and even charging rent for homestead land in the Padma. While cluster village projects organized to settle *khas* land in chars were found in the Upper Meghna and middle Ganges, these resulted in discontent among local people because of alleged irregularities in land allocation, and only involved a small fraction of the land and erosion victims.

NOTES

1. This report is based on inventory data documenting mauza residents' memories of the years of charland formation, appearance of natural vegetation, beginning of cultivation, and first human settlement. For the Brahmaputra-Jamuna it relates only to data on chars formed since 1920 and for the Meghna, Padma, and Ganges, to the most recent land formations and subsequent developments.

2. The figures are based on data in Appendix Tables A.1, A.2, and A.3 in the Socioeconomic Study.

3. Thérèse Blanchet, personal communication.

4. The char people whom the North West Regional Study (FAP 2) interviewed, "had moved to the char due to the loss of land and possessions in floods elsewhere. Indeed, in two perennial char areas, Rahmatchar and par-Diara, near Gaibandha, fifty percent of them said they had migrated to the char from the same place on the mainland." (1992:4-1).

5. According to Ralph Nicholas (1962:132), who did a comparative study of settlements in the deltaic and moribund floodplain of West Bengal, *Bangali* was the name by which the Mahisya cultivating *jati* (caste) referred to themselves throughout the state. He pointed out that the Mahisyas were such a large part of the population that, "It seems quite reasonable that they should equate themselves with the 'nation.'"

Chapter 3

COMPARATIVE ANALYSIS OF THE RIVERS

3.1 Coverage

The Charland Inventory is the result of a data collection exercise involving interviews with key informants and officials in 3,306 mauzas (revenue villages) covering the charlands of the four main rivers. For the Brahmaputra-Jamuna, 1,443 mauzas were surveyed in 1992, using a 1992 Landsat image. In 1993, the survey covered 639 mauzas along the Ganges, 485 on the Padma, and 739 on the Meghna and related the data to a 1993 Landsat image. The different survey dates, Landsat images used, and slight differences in the interview checklists used account for differences between rivers in the type of data in the tables.

The study covered an area of 8,444 km^2 (almost 6 percent of Bangladesh), and it was dominated by the Brahmaputra-Jamuna charlands, which accounted for 45 percent of the area covered (Table 3.1). The Brahmaputra-Jamuna and Meghna are each about 70 percent island or attached char mauzas, but in the Ganges and Padma, more than 40 percent of the total area is in unprotected mainland mauzas. Based on the dry season satellite images, the proportion of the charland area that is usable (vegetated or cultivated land) is remarkably consistent between rivers, averaging 63 percent (Table 3.2). The remaining area showed as either water in the dry season or as sand. The Ganges has relatively less water and more sand, reflecting

Table 3.1 Geographic Area of the Charland Survey Areas 1992-93

Location	Brahmaputra-Jamuna 1992	Ganges 1993	Padma 1993	Meghna 1993	Total 1992-93
	AREA (km^2)				
Island Char	1,482	476	427	897	3,283
Attached Char	1,191	456	205	510	2,362
Total Chars	2,673	932	632	1,408	5,645
Unprotected Mainland	1,158	636	456	549	2,798
Total Per River	3,831	1,568	1,088	1,957	8,444
% of Survey Total	45.4	18.6	12.9	23.2	100.0
	PERCENT BY RIVER				
Island Char	38.7	30.4	39.2	45.9	38.9
Attached Char	31.1	29.1	18.9	26.1	28.0
Total Chars	69.8	59.4	58.1	71.9	66.9
Unprotected Mainland	30.2	40.6	41.9	28.1	33.1

Table 3.2 Charland Area by Surface Type

Surface Type	Brahmaputra-Jamuna 1992	Ganges 1993	Padma 1993	Meghna 1993	Total (ha) 1992-93	Total (%) 1992-93
Water	21	15	28	36	2,049	24
Sand	14	20	13	3	1,050	12
Cultivated/vegetated	65	65	59	61	5,345	63

present low flows in the dry season. The Meghna has a higher proportion of water and less sand, reflecting the estuarine formation of the lower Meghna.

3.2 Demographic Profile

Almost 4.3 million people lived in the active floodplain of these four rivers in 1992-93, the majority of them along the Jamuna and Meghna (Table 3.3). Of the total floodplain population, 1.85 million (43 percent) live on chars, and they are concentrated in the Jamuna and Meghna. Because of high populations on island chars in these two rivers, 50 percent of the population covered lives on chars. In the Jamuna they are spread along the length of the river, but in the Meghna they are concentrated in the confluence and lower reach. These two rivers are the only ones where the island char population grew after the 1981 census (Table 3.4). The island char populations of the Ganges and Padma fell during this period as a result of morphological changes and channel widening (which converted these mauzas from mainland into island char, for example).

Overall population growth in the charlands between 1981 and 1992-93 was comparable to the national average growth rate, but population density is very uneven in the charlands. Unprotect-

Table 3.3 Population of the Charland Survey Areas 1992-93

Location	Brahmaputra-Jamuna 1992	Ganges 1993	Padma 1993	Meghna 1993	Total 1992-93
TOTAL POPULATION					
Island Char	512,996	54,395	55,630	325,485	948,506
Attached Char	407,052	141,245	92,506	260,635	901,438
Total Chars	920,048	195,640	148,136	586,120	1,849,944
Unprotected Mainland	897,712	495,788	470,519	579,667	2,443,686
Total Per River	1,817,760	691,428	618,655	1,165,787	4,293,630
% of Survey Total	42.3	16.1	14.4	27.2	100
PERCENT BY RIVER					
Island Char	28.2	7.9	9.0	27.9	22.1
Attached Char	22.4	20.4	15.0	22.4	21.0
Total Chars	50.6	28.3	23.9	50.3	43.1
Unprotected Mainland	49.4	71.7	76.1	49.7	56.9

Table 3.4 Increase in Charland Survey Area Population, 1981-93 (percent)

Location	Brahmaputra-Jamuna 1992	Ganges 1993	Padma 1993	Meghna 1993	Bangladesh Average 1981-92
Island Char	+33	-21	-43	+33	+26
Attached Char	+8	+18	-1	-3	+26
Unprotected Mainland	+14	+7	+20	+31	+26

ed mainland has population densities at least equal to the national average. Compared with the charlands as a whole, people are crowded into the unprotected mainland areas, partly as a result of erosion and partly because more stable and productive land is available in those areas. Attached chars consistently have higher population densities than island chars, but the difference is less marked in the Jamuna and Meghna, where island chars are able to support more than 40 percent of the national population density (Table 3.5). The combination of more stable islands and high proportions of island charland in these two rivers, may enable more people to remain in the chars, moving between islands as they emerge and erode.

Table 3.5 Charland Survey Area Population Density Relative to Bangladesh Average, 1991 (percent)

Location	Brahmaputra-Jamuna 1992	Ganges 1993	Padma 1993	Meghna 1993
Island Char	41.9	14.9	17.0	47.6
Attached Char	44.8	40.6	59.0	67.0
Unprotected Mainland	101.7	102.1	135.3	138.4

3.3 Erosion and River Morphology

During the past decade or so, all four rivers have tended to widen and take on more braided forms. Landsat image analysis gives an estimate of almost 87,000 ha lost due to bankline erosion (net of accretion), more than 50 percent of which was along the Brahmaputra-Jamuna (Table 3.6). On average, about 8,700 ha of mainland are lost each year to erosion by the main rivers. Within-channel changes, however, result in replacement of mainland by chars: more than 50,000 ha of char accreted (net) between 1984 and 1993. As shown above, the population density or carrying capacity of these chars is lower than the unprotected mainland. Moreover, there was a substantial net increase in the dry season water area of the main rivers in the period of analysis in all but the Ganges river, totalling 36,616 ha more water (Table 3.6). The land resource base of the charlands, therefore, is declining and becoming more crowded.

Average annual erosion rates vary greatly between rivers and river reaches. The upper Meghna is more or less stable, while the lower Meghna experienced extensive and extreme erosion during 1984-93, particularly on the right bank (Table 3.7). Sustained annual erosion rates of 100 meters or more over a 10-year period are notable, and occurred on both the lower Meghna and Padma, where satellite image analysis in the inventory reports reveals major changes in the river courses in this period. By comparison, the Meghna confluence, Jamuna, and Ganges experienced serious but somewhat less extreme erosion rates.

Differences in left and right bank erosion rates mean that the Jamuna, and to a lesser extent the Padma and Meghna, are migrating. Analysis of

Table 3.6 Total Area Eroded in the Charland Survey Areas, 1984-93 (ha)

Location	Brahmaputra-Jamuna 1980-92	Ganges 1984-93	Padma 1984-93	Meghna 1984-93	Total 1992-93
		BANKLINE			
Bankline Erosion	50,032	20,159	16,206	19,902	106,299
Bankline Accretion	6,767	9,085	2,094	1,359	19,305
Net Bankline Erosion	(43,265)	(11,074)	(14,112)	(18,543)	(86,994)
Annual Rate	(3,605)	(1,107)	(1,411)	(1,854)	(8,699)
		CHARLAND			
Net Charland Accretion	23,568	11,203	9,020	6,587	50,378
Annual Rate	1,964	1,120	902	659	5,038
		OVERALL			
Net Change	(19,697)	129	(5,092)	(11,956)	(36,616)
Annual Average Change	(1,641)	13	(509)	(1,196)	(3,662)

Areas of accretion in parentheses.

Table 3.7 Mean Bank Erosion Rate 1984-93* (m/yr)

	Brahmaputra-Jamuna	Ganges	Padma	Upper Meghna	Meghna Confluence	Lower Meghna
Right Bank	80	27	121	-9	20	295
Left Bank	46	67	38	7	94	47
Total	126	94	159	-2	114	342

*1980-92 for Brahmaputra-Jamuna.

Table 3.8 Changes in Average Width of the Main Rivers, 1984-93

Location	Brahmaputra-Jamuna	Ganges	Padma	Upper Meghna	Meghna Confluence	Lower Meghna
1973 Width	8,084					
1984 Width		4,367	5,689	3,406	7,981	5,737
1992 Width	10,611					
1993 Width		4,693	7,116	3,391	9,009	8,819
Total Change	2,527	326	1,427	(15)	1,028	3,082
Annual Rate (m/yr)	126	33	143	(2)	103	308

Table 3.9 Estimated Population Displaced by Erosion, 1981-93

Location	Brahmaputra-Jamuna 1981-92	Ganges 1981-93	Padma 1981-93	Meghna 1981-93	Annual Average
Bank Erosion	398,416	55,005	133,282	141,736	728,439
Per Annum	36,220	4,584	11,107	11,811	63,722

historic maps and satellite images shows that the Jamuna's centerline has moved an average of 4.3 km west since 1830, with a maximum westward movement of 13 km at its northern end. Analysis of a series of images from 1973-92 shows that this river is migrating westward at an average rate of 50 m per year.

The centerlines of all the rivers are moving, but all except the upper Meghna have also been widening. Table 3.8 shows that the Ganges has widened relatively slowly, but the Brahmaputra-Jamuna has widened over a 19-year period at well over 100 m a year averaged over its length. Similar widths may in time be achieved by the Padma, which carries the combined Jamuna and Ganges flows.

The effects of bankline erosion and widening of the river channel have been great. Analysis of population data, combined with the satellite image analysis, indicates that during the period 1981-92/93 an average of almost 64,000 people were displaced by bank erosion every year (Table 3.9), or 728,000 people over the whole period. More than half the displacement was along the Jamuna. This ignores changes in the chars within the changing banklines. Char erosion and accretion results in more people being displaced, and in the Brahmaputra-Jamuna the Charland Inventory found that 90 percent of the within-bank area had changed between char and water at least once during the period 1973-92. Therefore, the majority of char inhabitants are likely to have moved in that period. In the Kurigram sample area, 25 percent of homesteads were reported to have eroded in 1988 alone.

The growth of within-bank char areas means that some erosion victims can find a living in the chars. The study estimated the population that was displaced by bank erosion, but that could not have been accommodated in the charlands and instead shifted either to the charland fringe (sheltering on embankments) or left the charlands completely. According to these estimates, 187,000 people permanently left the Jamuna charlands, 19,000-44,000 left the Ganges, 123,000 departed the Padma, and about 120,000 left the Meghna. Hence, an estimated 462,000 people were displaced over an 11-year period, or 12 percent of the 1981 charland population.

Table 3.10 Cultivable Land Per Capita in Charland Survey Areas (ha)

Location	Brahmaputra-Jamuna 1992	Ganges 1993	Padma 1993	Meghna 1993	Bangladesh Average 1991
Island Char	0.14	0.35	0.24	0.12	0.09
Attached Char	0.18	0.21	0.15	0.13	0.09
Unprotected Mainland	0.12	0.11	0.08	0.08	0.09

3.4 Agriculture

The island and attached chars offer some advantages over mainland areas. Availability of cultivable land is higher than the national average (Table 3.10), whereas some unprotected mainland supports more people relative to the land resource than does Bangladesh as a whole. Cropping intensity reported in the inventory does not appear to be lower in the charlands than for Bangladesh as a whole (Table 3.11), yet the island and attached chars appear to be less productive than mainland areas. In part this reflects soil conditions; but the uncertainties of erosion, frequent flood damage, and control of land by large landowners may all be more important factors. Irrigated crops are scarce in many of the char areas, except for the Meghna, yet river water and groundwater are abundant. Given the uncertainties of the monsoon, the focus of agricultural development should be on the dry season—on high-value crops that can be harvested before the first flood peaks, for example.

Table 3.11 Cropping Intensity in Charland Survey Areas (percent)*

Location	Ganges 1993	Padma 1993	Meghna 1993	Bangladesh Average 1981-92
Island Char	174	162	147	172
Attached Char	189	190	143	172
Unprotected Mainland	186	179	153	172

*Data not collected for Brahmaputra-Jamuna.

Table 3.12 Percentage of *Kutcha* Housing, 1993*

Location	Ganges	Padma	Meghna
Island Char	61	53	52
Attached Char	32	50	40
Detached Mainland	NA	NA	23
Unprotected Mainland	38	30	30
Average	39	36	37

*Data not collected for Brahmaputra-Jamuna.

3.5 Standard of Living

A majority of char houses are completely *kutcha* (Table 3.12), and very often have walls and thatch roofs made from the catkin grasses that are such an important component of the charland environment and resource base. By comparison, on unprotected mainland 60-70 percent of houses have some corrugated iron in their construction. Charland housing, therefore, is less substantial, but is derived from local materials and is less costly to replace following flood damage or erosion.

Boat transport is critical to trade and to survival in times of erosion or flood in the charlands. Mechanized boats have become widespread in Bangladesh in the past decade. Table 3.13 shows that there are relatively more mechanized boats in the chars than in mainland areas, as might be expected, but it also indicates that there are relatively fewer boats in the Brahmaputra-Jamuna compared with the population. This implies a potential problem along this river for evacuation during extreme floods, and it may limit access to markets and the

Table 3.13 Households Per Mechanized Boat in the Charland Survey Areas

Location	Brahmaputra-Jamuna 1992	Ganges 1993	Padma 1993	Meghna 1993
Island Char	79	55	32	43
Attached Char	97	90	49	63
Unprotected Mainland	99	201	148	65

Table 3.14 Cattle Per Household in the Charland Survey Areas

Location	Brahmaputra-Jamuna 1992	Ganges 1993	Padma 1993	Meghna 1993	Bangladesh Average 1981-92
Island Char	0.88	1.24	0.67	0.74	1.33
Attached Char	0.71	1.54	0.64	0.56	1.33
Unprotected Mainland	0.84	1.08	0.60	0.90	1.33

ability of charland people to sell produce in the mainland.

Given the extensive areas of grassland in the chars and the risk of erosion and flood, cattle are an ideal asset and business since they can be moved to safety (unlike land) and can be sold in times of need. While the RRAs found that in some char areas cattle fattening during the winter and pre-monsoon is important (in the upper Meghna, for example, which has a combination of grazing, crop residues, and access to markets), cattle ownership per household in the chars is lower than the national average (Table 3.14). There would appear, therefore, to be opportunities to expand cattle raising in the charlands.

Service provisions are generally poor in the chars compared with mainland areas. This partly reflects difficulties of access, but also a peripheral position with respect to local administrative centers. There has been an emphasis in development work on building infrastructure, such as roads, that is clearly inappropriate in the chars, but alternative investments to improve life in the chars have neither been found nor implemented.

Chapter 4

JAMUNA SUMMARY

4.1 Jamuna Study Area

The western boundary of the Jamuna study area is the Brahmaputra Right Embankment and, in the north, the Kurigram embankment. The left bank boundary consists of the Indian border in the far north and, south of there, existing and proposed embankment alignments, including what would form the FAP 3.1 controlled flooding embankment between the Old Brahmaputra off-take and Jagannathganj Ghat.

4.2 Morphology

Until the late 18th or early 19th century, the Brahmaputra followed a different course than it does today. The Old Brahmaputra, now a withering distributary of the main river, was once the main channel of the river. A major avulsive event sometime between 1780 and 1830 caused the river to veer some 70 km westward of its old course, swinging to the west of the Madhupur Forest Tract. The new river channel it created, called the Jamuna, is still adjusting to the shift in location.

Its overall length of nearly 3,000 km and a catchment area of around 560,000 km^2, make the Brahmaputra one of the world's greatest rivers. In addition to a large catchment area, the Brahmaputra carries a very high sediment load, estimates of which put it on the order of 5 million metric tons per day in flood (Coleman, 1968), and averaging between 140 million (FAP 22, 1992) and 500 million m^3 per year (FAP 1, 1992). The combination of large and variable discharges of water and sediment is responsible for the Brahmaputra's braided pattern of multiple, shifting anabranches separated by chars ("braid bars"). Braided rivers are characterized by unstable banklines and rapid rates of lateral movement.

Annual flow in the Jamuna is characteristically high from June through September, a result of Himalayan snowmelt and monsoon rains, and very low in the winter. Annual flood peaks are on the order of 60,000 cumecs, three times the peak flow of the Mississippi (Coleman, 1968), and may exceed 100,000 cumecs in a 100-year return period flood (FAP 1, 1992).

Analysis of maps dating from 1830, 1914, and 1953, as well as eight dry season satellite images from various dates between 1973 and 1992, shows that the river has been steadily moving westward. Since 1830, the centerline of the Jamuna has shifted west at an average of 28 m per year, although it has moved less at nodal points such as the one near Bahadurabad ghat (middle reach), and just north of Aricha near the Ganges confluence, it has moved east since 1973.

The channel has also been widening, increasing from an average of 6.2 km in 1830 to 10.6 km in 1992. Furthermore, although the long-term widening trend (1830-1992) has averaged 27 m per year, analysis of the trend from 1973 to 1992 shows that widening has proceeded at an average of 140 m per year. The west bank eroded at an average of about 100 m per year between 1973 and 1992, but there were considerable local and short-term variations in erosion. Local bank erosion rates can be much higher, but rarely continue for many years. Analysis of erosion rates at half-kilometer intervals

along the right bank showed that in 80 percent of cases the duration of "catastrophic" erosion (more than 350 m per year) was two to four years. There is a less than 10 percent chance that catastrophic erosion will persist at a site for more than four years, or that erosion of 200-350 m per year will persist for more than seven years. Conversely, periods of very low rates of bank erosion, less than 25 m per year, have a less than 50 percent chance of lasting more than five years before higher rates of erosion recur.

4.3 Population and River Dynamics

Tables 4.1 and 4.2 summarize some of the most important inventory data by land type. The inventory estimates the total 1992 study area population to have been 1.82 million, of which 0.51 million lived in mauzas covering the 282 existing island chars. The attached char population was 0.41 million, and there were 0.90 million people on unprotected mainland, including setback land. Between 1981 and 1992 the total charland population grew by 17 percent. But within this period there were major shifts in the distribution of people due to bank erosion. Between 1980 and 1992, 50,000 ha of mainland eroded and only 6,000 ha accreted, a loss of 23 percent of the mainland in the study area. This mainland was estimated to have supported 400,000 people in 1981. Therefore, bank erosion must have forced 26 percent of the 1981 study area population to move between 1981 and 1992. Many apparently moved to island chars, while others moved to the diminishing area of setback land or left the charlands altogether.

Population growth in the mauzas within the 1980 banklines was very rapid over the period, increasing 92 percent as people moved to occupy new charland and were forced onto chars by bank erosion. Moreover, population density in the remaining unprotected mainland continued to increase, particularly on the west bank, where in 1992 it reached 1,342 persons per km^2 in mauzas unaffected by erosion, compared with 773 persons per km^2 in equivalent east bank mauzas. It appears that the higher rate of west bank erosion due to the changing river course has forced people into an ever-narrower band of land between the river and Brahmaputra Right Embankment (BRE).

FAP 1 (1992) predictions of the bankline in 2011 over 190 km of the river's 246 km length, imply erosion of about 49,500 ha. At current population densities and growth rates, that land would support about 578,000 people. Of those, 179,000 might find homes and land on newly accreted attached chars within the Jamuna charlands, the remaining 399,000 people would have to seek shelter in the island chars, in the diminishing setback land, or outside the charlands. The problem is likely to be worse in the lower reach of the river, where population densities are highest on the unprotected mainland. These estimates ignore the risk of earthquake, which could result in more dramatic changes in river course.

Future erosion is clearly a threat to the "permanent" settlements on the Jamuna mainland, but for the 500,000 or so people living on mid-channel chars it is an ever-present danger. Analysis of images covering 1973-92 shows that only 30 percent of vegetated land on chars persisted for 14 or more years. In fact, 66 percent of the total within-bank area changed between channel and char at least twice during the 19 years. The majority of the mid-channel population, therefore, must have moved at least once during the period due to normal erosion or submergence of their land (excluding peak floods).

In 1991, relatively few households migrated away; only 2 percent left their mauza, although there were locally higher rates, particularly in the lower west bank. On the other hand, 4 percent of households present in the study area in 1992 had moved into their mauza in the previous year, mainly to colonize accreting east bank attached chars. Seasonally, in-migration was more common than out-migration. This appears to be an adjustment to the hydrologic cycle, whereby people move into island chars and attached chars to cultivate and raise livestock during the dry season and leave when the land is flooded.

Table 4.1 Qualitative Summary of Differences between Char Land Types - Jamuna

Characteristic	Island Char	Attached Char	Unprotected Mainland
Land	Much sand and water, 48% vegetated.	Moderate sand and water, 61% vegetated.	Little sand or water, 91% vegetated.
Population	Lowest density, average 320 per km^2, but growth greater than national average since 1981.	Density slightly higher than islands (342 per km^2), but low growth.	Highest density, 773 per km^2. Caught up with national average since 1981 due to rapid growth as erosion victims concentrated in remaining mainland areas near their eroded land.
Migration in 1991	More in-migration, permanent moves as land reappears or in response to erosion elsewhere, and temporary moves to use seasonally available land.	More in-migration, particularly seasonal in-migration; attached chars may be subject to more rapid morphological change.	Localized out-migration linked to bank erosion, relatively less in-migration. Mauzas may be near capacity following past in-migration and bank erosion.
Infrastructure	Relatively poor high school and health facility provision. Access to mainland facilities constrained by river channels.	Relatively poor high school and health facility provision. Primary school provision same as other char types.	Relatively good high school and health facility provision. More markets.
Livestock	Low numbers relative to land area, but slightly higher per household than other land types.	Relatively low numbers.	High numbers relative to land, but this reflects population density not greater ownership.
Boats	Better availability of mechanized boats, but coverage patchy.	Boat availability same as in unprotected mainland.	About 100 households per mechanized boat.
Deaths	Concentrations of flood and disease deaths, particularly in upper and middle reaches.	1988 flood death incidence same as island chars, but relatively high in west bank.	High incidence of death due to disease, mainly in east bank, but fewer flood-related deaths.
Floods	Extensively flooded in 1988 for 22 days on average; about 58 percent flooded in 1991	Extent and duration of flooding in 1988 and 1991 similar to island chars.	1988 flood extensive and longer duration (28 days), about 33 percent flooded in 1991.

Source: FAP 16 Charland Study

Table 4.2 Summary of Mauza Inventory Data by Char Land Type - Jamuna

Parameter	Island Char	Attached Char	Unprotected Mainland	Bangladesh*
Area (ha)	148,248	119,010	115,756	14.4 million
Percentage water	31	21	7	na
Percentage sand	21	18	2	na
Percentage vegetated	48	61	91	na
1992 population	512,996	407,052	897,712	109.9 million
Population per km^2 in 1992	320	342	776	763
Percentage increase, 1981-92	33	8	14	26
Cultivable land per capita (ha) in 1992	0.14	0.18	0.12	0.09
% permanently out-migrating in 1991	3	4	2	na
% seasonally in-migrating in 1991	3	6	3	na
% mauzas with primary school	62	61	61	74
% mauzas with high school	10	7	17	13
% mauzas with health facility†	8	11	22	4
% households mainly farming	46	45	44	na
% households mainly day laboring	42	43	36	na
Cattle per household	0.88	0.71	0.84	1.33
Households per mechanized boat	79	97	99	na
1988 flood-related deaths per 100,000	81	81	57	1.4
% mauzas reporting livestock death in 1988 flood	79	67	32	na
1988 % area flooded	91	84	93	46
1991 % area flooded	58	52	33	na
1988 mean flood duration (days)	22	23	28	na
1991 mean flood duration (days)	12	13	11	na

Source: FAP 16/19 inventory and satellite image analysis

*Source: BBS (1993), except flood data, which is from Rogers, *et al.* (1989). Population figures are for 1991. Comparisons are for rural Bangladesh.

†Facilities below the union health center level, such as private doctors, may have been included in the inventory.

4.4 Resource Base

Based on analysis of March 1992 Landsat imagery, the study area covered about 383,000 ha of char land; of this, 21 percent was water, 14 percent was sand, and 65 percent was cultivated or vegetated. Within the banklines of the river, 52 percent of the land was either sand or water and 48 percent was vegetated or cultivated. The area of vegetated (productive) island chars has grown more or less proportionally with the widening of the river, increasing by about 26,000 ha between 1980 and 1992. The proportion of vegetated char within the banklines has only increased from 45 to 48 percent.

The resource base of the Jamuna charlands is dominated by farming: 46 percent of households work the land for a living, and another 40 percent depend on day laboring, which is predominantly agricultural. Only 5 percent of the area households fish for a living, and for 10 percent fishing is a secondary source of income. There is more available cultivable land per capita in the Jamuna charlands than the national average (0.14 ha compared with 0.09 ha for the nation), and on the mainland 70 to 80 percent of mauza areas are reported to be cultivated. Many island char mauzas have less than 50 percent of their land cultivated. Dry-land crops, mainly millet and groundnuts, are dominant in about 30 percent of the mauzas, which are concentrated in the main channel chars. Aus and aman paddy are also locally important in the middle reaches of the river, but boro paddy is mainly grown in the unprotected mainland, particularly in the lower east bank. Despite the abundant supply of water in the chars, there is very little irrigation and virtually no HYV boro is grown in these areas.

Despite the impression of plentiful grazing and high livestock numbers, reported numbers of cattle and buffaloes in the charlands are lower (only 0.82 per household) than in Bangladesh as a whole (but there are slightly higher than average numbers of goats and sheep). Seasonal flooding, or losses in the 1987 and 1988 floods, may have depressed cattle numbers.

4.5 Flood Hazard

In 1987, based on satellite image analysis, only 9 percent of the char area within the Jamuna banklines was above water during the flood peak. In 1988, more than 90 percent of the area of mauzas in the study area was reported to have been flooded (including unprotected mainland) for an average of 24 days. By comparison, in the "high normal" flood year of 1991, 51 percent of land was reportedly flooded. There was a trend toward more extensive flooding in the north and less extensive in the south, and durations fell from north to south but averaged 12 days. There have been minimal flood deaths in the study area since 1988, but in that year more than 860 people were reportedly killed as a result of flooding, particularly in the upper and middle reaches of the river. Epidemic diseases were reported to have killed more people during the period 1988-92, particularly in the island chars of the upper and middle reaches.

4.6 Services and Infrastructure

Health care facilities in the Jamuna study area are concentrated in the unprotected mainland. Despite the fact that there appear to be more facilities relative to the population than in other parts of Bangladesh, in 31 percent of inhabited mauzas there was no recollection of a visit by a health worker. The char areas fare relatively well in primary education: about 61 percent of inhabited mauzas have a primary school (the same as in the unprotected mainland, but less than in Bangladesh as a whole), but many children still do not live close to a school. There are 28 percent more children per high school in the charlands than in Bangladesh as a whole, and those schools are concentrated on the mainland, which, because access requires boat transport, makes them inaccessible for most families.

Access problems limit the use of both health and education facilities, and river transport is also vital for coping with floods and erosion in the island chars. Local boat transport is entirely within the private sector, and mechanized boats have

come to play an important role in linking the chars with such mainland facilities as markets. Availability of mechanized boats is slightly higher in the island chars (about 80 households per boat) compared with the unprotected mainland (about 100 per boat). Yet flooding and erosion could mean that a whole village would need to evacuate by boat in a short time. There are an average of 13 households per non-mechanized boat throughout the area, but such small boats are hazardous during peak floods.

4.7 Future Changes and Interventions

There are 1.82 million people living in the Jamuna charlands who will continue to be at risk from flooding. At present, flood risk is greater in the upper reach of the river, which experienced more extensive flooding for longer durations in 1991 compared with the middle and lower reaches. Flood modelling by FAP 25 indicates that confinement of the river by the proposed Jamuna multipurpose bridge, and by sealing and extending existing embankments, may raise flood levels and increase the risk of flooding for the 0.58 million people living in the middle and northern lower reaches. The proposed bridge may also result in major changes in the pattern of sediment transport and river morphology both up- and downstream of the bridge site. This could affect many char dwellers and alter the conclusions of this report. Modelling of such impacts linked with the charland inventory is needed.

Many char people are also at risk from erosion. Most of those on island chars can expect to move at least once in the next 20 years because of erosion. Using FAP 1 predictions for the banklines in the year 2011, an estimated 578,000 people may lose their homes and land to bank erosion by that year. This will increase population pressure both on the island chars and the remaining mainland. River training works may be a viable way to stem this loss of land and consequent population displacement. Measures to stabilize and prolong the lives of island chars could also benefit the 0.51 million people living on the Jamuna chars.

Chapter 5

GANGES SUMMARY

5.1 Ganges Study Area

The Ganges study area is a narrow band of charland stretching 185 km northwest to southeast. It is bounded by embankments along most of the left (north) bank, except for Nawabganj, and along most of the Bangladesh reach of the right (south) side. The international border is the study area boundary along the first 90 km of the south side of the river between Shibganj and Bheramara. Its downstream limit is the upstream side of the confluence with the Jamuna.

5.2 Morphology

The path of the Ganges covered by this study has followed the course described above for about 500 years. In the 15th or 16th century the river swung eastward from a route through the Hoogly to follow a course close to that of the present day Gorai, but by the 1770s it had moved farther east into its present alignment. There have been many changes downstream, most notably the joining of the Jamuna to the Ganges between the 1780s and 1830 and the creation of the Padma. These changes are not thought to have had much impact on the Ganges, except that a backwater effect in the early monsoon probably results in higher and earlier flood levels in the lower Ganges. The most recent main change has been a major decline in dry-season discharge: the mean flow for March in 1989-92 at Hardinge Bridge was only 25 percent of the mean for 1934-74 (FAP 4, 1993).

The monsoon season flow of the Ganges is about 20 times the dry season flow. The river has a total catchment of some 1.1 million km^2. The Ganges, like the other main rivers, carries a very heavy sediment load, the highest estimates of which put it at an average of 450 million m^3 per year (FAP 4, 1993). The Ganges is a wandering river that may be in a state of dynamic equilibrium, characterized by rapid bank erosion rates within its active corridor. It typically alternates between phases of meandering and phases when a more braided channel system develops.

Flow in the Ganges is characteristically high from July through September—the result of Himalayan snowmelt and monsoon rains—and very low in the winter. In a 20-year return period flood the flow exceeds 70,000 cumecs (FAP 25, 1992), three times the peak flow of the Mississippi (Coleman, 1969).

The Ganges has not changed course significantly in the past 200 years, but within the active corridor there have been major changes. In 1779, the lower reach was strongly meandering, but by the mid-20th century it was reasonably straight and heavily braided. This situation has continued to 1993, but in recent years the main channel in the lower reach has narrowed due to net accretion. In the upper and middle reaches, the river is meandering. Analysis of dry season satellite images from 1984 and 1993 shows that this meandering has become more pronounced and involved substantial widening of the river at meander bends. These changes appear to follow a cyclical pattern.

The maximum width of the river in 1984 was 10 km, but by 1993 it was 11.7 km. Erosion and widening rates locally have been much higher:

near Nawabganj in the upper reach, for instance, the bankline moved up to 6 km north in nine years, an erosion rate of 665 m per year sustained over almost a decade. Net erosion rates of more than 200 m per year for the nine-year period were found at less than 14 percent of cross-sections. Averaged over reaches, however, erosion and accretion rates were much slower than these extremes, which are comparable to rapid erosion rates on the Padma and Jamuna.

Consequently, mainland has been lost to the river, but the area of vegetated charland in the upper reach has increased in proportion to this loss of mainland. Meanwhile, in the middle and lower reaches there has been considerable within-bank accretion of chars, and in the lower reach, net bankline accretion.

5.3 Population and River Dynamics

Tables 5.1, 5.2, and 5.3 summarize some of the most important inventory data by land type and reach. The inventory estimates the total 1993 study area population to have been 697,000, of which about 54,000 lived in island char mauzas. The attached char population was 141,000, and there were 501,000 people on unprotected mainland. Between 1981 and 1993 the total charland population grew by only 6 percent, but in this period there were major shifts in the distribution of people, partly due to bank erosion.

Between 1984 and 1993 in the surveyed mauzas, just over 13,500 ha of mainland eroded, and just over 5,000 ha accreted, a net loss of 9 percent of study area mainland. This eroded land was estimated to have supported about 60,000 people in 1984. Therefore, bank erosion, mainly affecting people in the upper and middle reaches, must have forced 8 percent of the 1984 population to move by 1993.

The channel in the upper reach widened in this period, and some areas were converted from mainland to char. Since population growth was very low, the estimated 19,000 or so people displaced by erosion left the charlands of this reach.

A total of about 11,000 ha of vegetated chars have emerged within the banklines since 1984. This has just about compensated for the area of mainland lost, but there are many fewer people per ha in the island chars than in the mainland. Char formations in the middle reach were basically stable and experienced moderate population growth, but mauzas that are now island chars generally experienced a population decline after 1981 because a number of them were converted from mainland to island char in that period. Population has grown quite rapidly in some mainland mauzas unaffected by erosion since 1984 in the upper and lower reaches. Population in the middle reach mainland unaffected by erosion fell, however. The reasons for this change in a fairly remote border area that was badly affected in the 1988 flood deserve further investigation. Taking into account population trends in areas that did not experience morphological changes, it is thought that between 19,000 and 44,000 of the people displaced from eroded land left the Ganges charlands.

It is impossible to make erosion rate predictions for the Ganges based on a comparison of images covering only nine years. The tendency for the river to meander in the upper and middle reaches means that land within the active river corridor is expected to be subject to rapid bank erosion at some time in the next 50 years. The braided lower reach may have less erosion risk, although the tendency for recent centerline shifts and for a single channel to emerge need to be monitored.

Erosion will periodically threaten settlements on attached chars and mainland within the active corridor of the Ganges, but for the 54,000 people living on mid-channel chars it is an ever-present danger. Inventory data on homestead erosion since 1987 showed low losses along the banklines, which is consistent with bank erosion and settlement of the increasing within-channel char area. The reports indicate that about 6 percent of households in the Ganges study area were displaced by erosion of some kind between 1987 and 1992.

Table 5.1 Qualitative Summary of Differences between Char Land Types - Ganges

Characteristic	Island Char	Attached Char	Unprotected Mainland
Land	Very sandy soil, only 41% vegetated, less under water than in other rivers.	Moderate amount of sand, 66% vegetated.	Little sand or water, 84 % of land vegetated, mostly cultivated.
Population	Very low, average 114 per km^2 in 1993, population decreased in all reaches as accretion was mostly on attached chars.	Moderate density (310 per km^2), greatest increase in study area, but less than national average.	Highest density, 779 per km^2, low growth since 1981, some bank erosion, but other factors involved, depopulation needs further study.
Erosion/Accretion Pattern	Net accretion: conversion of sand to land since 1984.	Some land converted from island char since 1984. Erosion in upper reach but accreted elsewhere.	Erosion in upper reach north bank and in middle reach south bank where maximum population displaced.
Migration in 1992	Some permanent in-migration as chars stabilize and become cultivable following recent accretion. Minimal seasonal migration.	Some permanent in-migration following recent accretion. Minimal seasonal migration.	Little migration, but some seasonal out-migration, presumably to find work in urban centers.
Infrastructure	Under 50% of mauzas with primary school, few health facilities. Access difficult.	Lowest primary school provision.	Relatively good service and infrastructure provisions.
Occupations	More day laborers and fewer farmers with own land, more fishermen (7%) than other land types.	High percentage of farmers.	Few (2%) fishermen, more in business and service.
Agriculture	Lowest cropping intensity, groundnuts and L boro important.	Intensive cultivation, pulses and aus paddy dominate.	Aus dominates in upper reach, sugarcane relatively important.
Livestock	National average ownership, but numbers low relative to land available.	Ownership high.	High numbers relative to land area, low ownership.
Boats	More mechanized boats than elsewhere in Ganges chars.	Relatively few mechanized boats.	Very few mechanized boats for population.
Deaths	Highest flood and disease death rates, mainly in middle reach.	Few hazard related deaths.	Few hazard related deaths.
Floods	Normal floods longer and more extensive than other land types, 33% houses destroyed in 1988.	Normally least extensive flooding; 23% houses destroyed in 1988.	Normal floods shorter duration, but greater losses in 1988 than attached chars.

Source: FAP 16 Charland Inventory

Table 5.2 Summary of Mauza Inventory Data by Char Land Type - Ganges

Parameter	Island Char	Attached Char	Unprotected Mainland	Bangladesh*
Area (ha)	47,622	45,578	63,600	14.4 million
Percentage water	22	15	9	na
Percentage sand	37	19	7	na
Percentage vegetated	41	66	84	na
1993 population	54,395	141,245	495,788	109.9 million
Population per km^2 in 1993	114	310	779	763
Percentage increase, 1981-93	-21	+18	+7	+26
Cultivable land per capita (ha) in 1993	0.35	0.21	0.11	0.09
% permanently in-migrating in 1992	2.8	2.0	1.4	na
% seasonally out-migrating in 1992	3.0	0.2	1.7	na
% mauzas with primary school	47	43	57	74
% mauzas with high school	9	10	21	13
% mauzas with health facility†	7	11	16	4
% households mainly farming	36	46	43	na
% households mainly fishing	7	4	2	na
Cropping Intensity	174	189	186	172
Cattle per household	1.24	1.54	1.08	1.33
Households per mechanized boat	55	90	201	na
1988 flood deaths per 100,000	162	24	22	1.4
1988 % area flooded	100	98	99	46
1989-92 mean % area flooded	83	65	69	na
1988 mean flood duration (days)	44	38	37	na
1989-92 mean flood duration (days)	26	21	19	na
% houses flooded in 1988	88	84	86	na
mean % houses flooded in 1989-92	4	3	2	na
% houses destroyed in 1988	33	23	27	na
mean % houses destroyed in 1989-92	1	0	0	na

Source: FAP 16/19 inventory and satellite image analysis

*BBS (1993), except flood data, which is from Rogers, *et al.* (1989). Population figures are for 1991. Comparisons are for rural Bangladesh.

†Facilities below the union health center level, such as private doctors, may have been included in the inventory.

Table 5.3 Summary of Mauza Inventory Data by Reach - Ganges

Parameter	Upper Reach	Middle Reach	Lower Reach	Bangladesh*
Area (ha)	60,926	41,242	54,632	14.4 million
Percentage water	13	16	16	na
Percentage sand	15	27	19	na
Percentage vegetated	72	57	65	na
1993 population	312,884	119,251	259,293	109.9 million
Population per km^2 in 1993	513	289	474	763
Percentage increase, 1981-93	+12	-24	+18	+26
Cultivable land per capita (ha) in 1993	0.14	0.20	0.14	0.09
% permanently in-migrating in 1992	1.5	2.6	1.3	na
% seasonally out-migrating in 1992	2.4	1.1	0.6	na
% mauzas with primary school	63	44	49	74
% mauzas with high school	22	20	13	13
% mauzas with health facility†	15	8	15	4
% households mainly farming	45	39	42	na
% households mainly fishing	2	3	4	na
Cropping Intensity	191	173	185	172
Cattle per household	1.60	0.49	1.01	1.33
Households per mechanized boat	125	147	153	na
1988 flood deaths per 100,000	11	100	29	1.4
1988 % area flooded	97	100	100	46
1989-92 mean % area flooded	62	85	72	na
1988 mean flood duration (days)	30	49	39	na
1989-92 mean flood duration (days)	16	29	20	na
% houses flooded in 1988	71	86	96	na
mean % houses flooded in 1989-92	4	1	2	na
% houses destroyed in 1988	27	25	27	na
mean % houses destroyed in 1989-92	1	0	0	na

Source: FAP 16/19 inventory and satellite image analysis

*BBS (1993), except flood data, which is from Rogers, *et al.* (1989). Population figures are for 1991. Comparisons are for rural Bangladesh.

†Facilities below the union health center level, such as private doctors, may have been included in the inventory.

In 1992, less than one percent of households migrated out of their mauzas. On the other hand, 1.6 percent of households in the study area in 1993 had moved into their mauza in the previous year, mainly to colonize accreting island and attached chars in the middle reach, where up to 7 percent of inhabitants had moved in the previous year. Seasonal in- and out-migration are reported to be rare and mostly occur in island chars and the upper reach. There apparently was little movement into the chars to cultivate and raise livestock during the dry season. In- and out-migration may be low because urban areas, such as Rajshahi and Pabna, border the study area and are in commuting distance of the chars.

5.4 Resource Base

Based on analysis of March 1993 Landsat imagery, the study area covered about 156,800 ha; of this, 15 percent was water, 20 percent was sand, and 65 percent was cultivated or vegetated. Within the banklines, 29 percent of the area was water, 36 percent sand, and only 35 percent was vegetated or cultivated. The area of vegetated (productive) island chars increased more than proportionally with the widening of the river, increasing by about 11,000 ha (more than 45 percent) between 1984 and 1993.

The resource base of the Ganges charlands is dominated by farming: 43 percent of households cultivate land for a living and 40 percent depend on predominantly agricultural day labor. Only 3 percent of households fish as a primary occupation, and it is a secondary source of income for another 6 percent. Even in the island chars only 6 percent of households mainly fish. The Ganges is now a minor riverine fishery compared with the other main rivers partly because there is little adjacent open floodplain available for fish. The Ganges used to be a major spawning route for migrating hilsha (*Ilish ilish*), but since construction started on the Farakka Barrage the catch in India is reported to have fallen by 95 percent (Verghese, 1990). The hilsha catch in the Indian reach of the Ganges is now improving as the Hoogly has become a new migration route since locks were constructed on the Farakka supply canal.

There is much more cultivable land available per capita in the Ganges charlands compared to the national average (0.15 ha compared with 0.09 ha for the nation). The Ganges mainland is similar to the national average, but in island chars there is much more cultivable land per capita. The majority of land areas are reported to be cultivated. Cropping intensity is high, averaging 185 percent. Sandy land is concentrated in the island chars (60 percent sand), and is more common in the middle reach than in the upper. Dry-land crops, almost exclusively groundnuts, are only common in the island chars, and are particularly so in the middle reach. A wide variety of winter crops are grown, but pulses (*dal*) are more important than in the other main river charlands.

Broadcast aus (early monsoon season paddy) dominates cropping throughout the area, and in the upper reach mainland virtually all land is under the crop. Aus appears to be damaged by floods about two years in 10, but aman is reported to be more damage-prone in much of the area. B. aman is only significant in the setback areas of the middle and lower reaches. Transplanted aman, although offering higher yields, is rarely grown. Sudden flood peaks make paddy cultivation in the late monsoon risky. Since the area also has low rainfall, the main cropping sequence is aus, which can be harvested before flood peaks, followed by pulses sown early on residual moisture. Local and HYV boro (winter-sown paddy) are uncommon and restricted, respectively, to low land and some areas with irrigation. Despite the abundant supply of water, there is little irrigated land in the chars.

Numbers of cattle and buffaloes in the Ganges charlands are similar (1.2 per household) to the Bangladesh average, as are numbers of goats and sheep. The higher level of livestock ownership in the chars reflects the abundant dry season grazing, yet the numbers relative to land area are low. There may be potential to increase livestock numbers, but it may be constrained by monsoon flood risk and land tenure systems.

5.5 Flood Hazard

In 1987, 74 percent of cultivated land in the Ganges study area was reported to have been flooded, and in 1988, 99 percent flooded for an average of 39 days. By comparison, the average for 1989-92 "normal" monsoon conditions is 70 percent of land flooded for an average of 21 days. There was a trend toward less extensive and shorter-duration flooding in normal monsoon conditions in the upper reach, and for the middle reach to be flooded more extensively for longer. This is associated with the area of island chars in that reach, as these chars are flooded more in normal years. There was no difference in flooding between reaches or land types in 1988.

The 1988 flood was estimated to be about a 1-in-60-year event in the lower reach; the return period in the other reaches is uncertain. In that year, 86 percent of houses in the Ganges charlands were flooded and 27 percent were destroyed. Although the proportion flooded increased going downstream, the proportion destroyed was constant. On average, only 3 percent of houses were flooded in each year during the 1989-92 period. Only in 1988 was there a substantial number of flood-related deaths: about 231 people were killed, 38 percent of them in the middle reach island chars. Epidemic diseases were reported to have killed more people during the period 1988-92, particularly in the same areas that reported the most flood deaths.

5.6 Services and Infrastructure

Study area health care facilities and coverage by health workers appear to be good, but health care facilities are distant from middle reach island char people. Most people normally drink tubewell water, but in the 1988 flood, 37 percent of all households and 74 percent of island char households drank river water, seriously compromising their health. Only 53 percent of inhabited mauzas have a primary school, more than 20 percent lower than the national average, and the chars have the fewest schools. There are 35 percent more children per primary school in the study area than in Bangladesh as a whole. Moreover, access to high schools is difficult for island char children.

Access problems limit the use of both health and education facilities. River transport is vital in a normal monsoon, as well as for coping with floods and erosion in the island chars. In the dry season, however, people may have to walk long distances. Local boat transport is entirely within the private sector, and mechanized boats have come to play an important role in linking the island chars with such mainland facilities as markets. Mechanized boats are only numerous in the island chars of the Ganges (about 55 households per boat) compared with the unprotected mainland (about 201 per boat). In flood times there is likely to be a shortage of boats compared with other charlands since there are an average of 19 households per non-mechanized boat throughout the area, and people may have to evacuate their homes as flood waters rise.

5.7 Future Changes and Interventions

There are 691,000 people living in the Ganges charlands who will continue to be at risk from flooding. Flood risk currently is greatest in the middle reach of the river, which experiences more extensive flooding for longer durations every year. The upper and lower reaches were equally severely affected by the 1988 flood. Much of the Ganges is already embanked. Flood modelling by FAP 25 indicates that putting embankments close to the river in the lower reach could, in combination with backwater effects caused by interventions in the Jamuna, raise water levels in the lower reach in a 1988-magnitude flood by about 18 cm (FAP 25, 1993). This risk needs to be borne in mind in planning for these charlands; in 1988 an increase of about 25 cm in flood water level over the 1987 peak level resulted in an additional 8,000 houses (about 19 percent) in this reach being destroyed.

Many char people are also at risk from erosion, which displaced about 60,000 people in the Ganges charlands in the past decade. There is no reason to believe that the next decade will be any

different as meanders continue to move and evolve. River training works may be possible where the more predictable meander system can be stabilized, but there will still be risks. The area of island chars has been increasing rapidly, however, and low cost measures to stabilize island chars might create more land, increase its productivity, increase the duration of settlement, and—if coupled with flood proofing—reduce risks.

Chapter 6

PADMA SUMMARY

6.1 Padma Study Area

The Padma study area is bounded by embankments along most of the west (south) bank. On the east bank, an existing embankment and flood-limiting roads were used as the boundary. The area of study extended from the south side of the Ganges at the confluence with the Jamuna and Padma to the narrow single channel reach of the Padma near Mawa. The Meghna confluence was examined as part of the Meghna Inventory (Chapter 7). The Padma study area, while only some 84 km long, constitutes one of the most dynamic of Bangladesh's riverine charlands.

Along the Padma, charlands that are separated from the mainland by small channels (former distributaries of the river, for example) have been classified and treated as attached chars.

6.2 Morphology

Before the mid-19th century the Padma did not exist. In the 1770s, the Ganges flowed south of the present Padma and joined the Bay of Bengal separately from the Brahmaputra. By 1830, following the Brahmaputra's diversion into the Jamuna, the Padma formed downstream of the Ganges-Jamuna confluence, and continued for some time to follow the course of the Ganges. Between 1830 and 1857 the Padma broke through a band of resistant sediments to join the Meghna at its present confluence. The river's alignment has remained the same since then, although its channel has progressively widened.

The Padma, as previously mentioned, is highly dynamic. It has a total catchment of some 1.7 million km^2—the combined catchments of the Brahmaputra and Ganges. It also carries the largest sediment load in Bangladesh, the highest estimates of which put it at an average of one billion m^3 per year (FAP 4, 1993). The Padma is a wandering river characterized by unstable banklines and rapid rates of lateral movement. It typically alternates between phases of meandering and phases when a more braided channel system develops.

Flow in the Padma is characteristically high from June through September—the result of Himalayan snowmelt and monsoon rains—and very low in the winter. In a 100-year return period flood (FAP 4, 1993) the flow exceeds 100,000 cumecs, five times the peak flow of the Mississippi (Coleman, 1969).

The Padma has shown some tendency to move northward, and has gradually widened since its formation. In the mid-20th century it was relatively straight but heavily braided, but by 1973 it had a more meandering course. The river straightened again by 1984, and in 1993 it has a braided middle reach and a large meander in the lower reach. Analysis of dry season satellite images from 1984 and 1993 shows that the centerline of the lower reach shifted 2 km south near Sadarpur and more than 1 km north near Mawa. These changes are largely the result of widening caused by rapid west (right) bank erosion.

In 1984, the maximum width of the Padma was 8.5 km, but by 1993 it was 10.7 km. Erosion and

widening rates locally have been much higher: in Sadarpur (right bank), for instance, the bankline moved southwest 5.5 km in nine years, an erosion rate of 623 m per year sustained over almost a decade. Net erosion rates for the nine-year period in excess of 200 m per year were found at 14 percent of the river's cross-sections. This indicates prolonged, rapid—even "catastrophic"—bank erosion, particularly in the lower reach, compared with analysis of erosion rates over a 19-year period on the Jamuna, where such rapid erosion rates rarely persist for more than four or five years.

Consequently, mainland has been lost to the river, but the area of vegetated charland has increased and formed a higher proportion of the within-bank area in 1993 than in 1984.

6.3 Population and River Dynamics

Tables 6.1, 6.2, and 6.3 summarize some of the most important inventory data by land type and reach. The inventory estimates the total 1993 study area population to have been 618,000, of which almost 56,000 lived in mauzas covering the 31 existing island chars. The attached char population was 92,500, and there were 470,500 people on unprotected mainland, including setback land. Between 1981 and 1993 the total charland population grew by only 6 percent, but within this period there were major shifts in the distribution of people due to bank erosion. Between 1984 and 1993, just over 16,000 ha of mainland eroded, and only 2,000 ha accreted, a loss of 24 percent of the mainland in the study area. This area of eroded mainland was estimated to have supported about 133,000 people in 1984; therefore, bank erosion must have forced 21 percent of the 1984 study area population to move between 1984 and 1993. This erosion mainly affected people in the middle and lower reaches.

The upper reach was stable in this period, population displacement was minimal, and a few chars emerged and were settled. In the middle and lower reaches, some 9,000 ha of vegetated chars have emerged within the banklines since 1984, yet this has not compensated for the loss of mainland. Although char formations in the middle reach underwent considerable change, the char population was unchanged. Meanwhile, population density in the lower reach island chars increased rapidly, although it is still much lower than the mainland density. There has been quite rapid population growth in mainland mauzas unaffected by erosion since 1981, particularly in the east (north) bank where population density grew from 920 people per km^2 to 1,354 people per km^2. The population of mainland that has not eroded is consistent with national population growth rates, and some 8,000 people may have been absorbed into the within-bank charlands, implying that some 123,000 people were forced to leave the study area as a result of erosion since 1981.

It is impossible to make erosion rate predictions for the Padma based on a comparison of images covering only nine years. If the meandering tendency continues, however, and it attacks the nodal point near Mawa, then more people are likely to be displaced. Alternatively, the river may start to braid and switch back to a northern channel near Srinagar, in which case erosion rates and population displacement may slow down.

Future erosion is clearly a threat to the mainland settlements along most of the Padma, but for the 55,000 people living on mid-channel chars it is an ever-present danger. The inventory compiled data on homestead erosion in all areas, including the island chars. High numbers of homesteads were reported lost even in normal flood years between 1989 and 1992, including erosion of houses in the densely populated upper reach. The reports indicate that about 20 percent of households in the Padma study area were displaced by erosion of some kind between 1987 and 1992.

In 1992, less than one percent of households migrated out of their mauzas. On the other hand, 3 percent of households in the study area in 1993 had moved into their mauza in the previous year. Most of these people had settled accreting island chars, particularly in the middle and lower reaches

Table 6.1 Qualitative Summary of Differences between Char Land Types - Padma

Characteristic	Island Char	Attached Char	Unprotected Mainland
Land	Very sandy soil, only 31% vegetated, most of area under water.	Moderate amount of sand, 67% vegetated.	Little sand or water, most of land cultivated.
Population	Very low, average 130 per km^2 in 1993, population increased in lower reach as new chars accreted.	Moderate density (450 per km^2), and almost static population.	Highest density, 1,032 per km^2, only land type with growth since 1981 despite bank erosion.
Erosion Pattern	Much change in char formations.	Rapid erosion of south bank in middle reach.	Most affected by erosion on east bank and in lower reach west bank where maximum population displaced.
Migration in 1992	Much in-migration as chars stabilize and become cultivable following recent accretion. Mainly permanent migration.	Little migration of any type.	Much seasonal out-migration, due to high population density and ease of communications to urban centers (Dhaka and Faridpur).
Infrastructure	Under 50% of mauzas with primary school, lack health facilities. Access difficult.	Worst school provision, and few health facilities.	Relatively good service and infrastructure provisions.
Occupations	Fewer day laborers, 20% mainly fish.	High percentage of day laborers.	Few (8%) fishermen, more in business and service.
Agriculture	Lowest cropping intensity, dry-land crops and aus dominate.	Diverse cropping, dry-land crops still important but more B aman.	L & HYV boro relatively important, aus and B aman equally important.
Livestock	Low numbers relative to land.	Ownership low, same as in island chars and unprotected mainland.	High numbers relative to land area, low ownership.
Boats	Good availability mechanized boats.	Similar availability to island chars.	Very few mechanized boats for population.
Deaths	Flood and disease death rates higher than unprotected mainland.	Highest incidence of hazard related deaths.	Lowest incidence of hazard related deaths.
Floods	Normal floods longer and more extensive than other land types, high incidence of house damage in 1988.	Least extensive flooding but long duration in 1988, highest destruction: 50% destroyed in 1988.	Normal floods quite extensive, fewer houses destroyed in 1988; but all houses flooded in 1988 in all three land types.

Source: FAP 16 Charland Inventory

Table 6.2 Summary of Mauza Inventory Data by Char Land Type - Padma

Parameter	Island Char	Attached Char	Unprotected Mainland	Bangladesh*
Area (ha)	42,683	20,523	45,578	14.4 million
Percentage water	47	20	15	na
Percentage sand	22	13	4	na
Percentage vegetated	31	67	81	na
1993 population	55,630	92,506	470,519	109.9 million
Population per km^2 in 1993	130	450	1,032	763
Percentage increase, 1981-93	-43	-1	+20	+26
Cultivable land per capita (ha) in 1993	0.24	0.15	0.08	0.09
% permanently in-migrating in 1992	9.8	1.3	2.7	na
% seasonally out-migrating in 1992	3.0	1.0	7.7	na
% mauzas with primary school	45	41	55	74
% mauzas with high school	16	10	22	13
% mauzas with health facility†	2	8	23	4
% households mainly farming	44	40	43	na
% households mainly fishing	20	11	5	na
Cropping Intensity	162	190	179	172
Cattle per household	0.67	0.64	0.60	1.33
Households per mechanized boat	32	49	148	na
1988 flood deaths per 100,000	54	70	28	1.4
1988 % area flooded	100	100	100	46
1989-92 mean % area flooded	72	47	61	na
1988 mean flood duration (days)	41	46	39	na
1989-92 mean flood duration (days)	33	24	27	na
% houses flooded in 1988	100	96	98	na
mean % houses flooded in 1989-92	4	3	3	na
% houses destroyed in 1988	40	50	24	na
mean % houses destroyed in 1989-92	1	1	1	na

Source: FAP 16/19 inventory and satellite image analysis

*BBS (1993), except flood data, which is from Rogers, *et al.* (1989). Population figures are for 1991. Comparisons are for rural Bangladesh.

†Facilities below the union health center level, such as private doctors, may have been included in the inventory.

Table 6.3 Summary of Mauza Inventory Data by Reach - Padma

Parameter	Upper Reach	Middle Reach	Lower Reach	Bangladesh*
Area (ha)	19,473	51,344	37,965	14.4 million
Percentage water	24	29	30	na
Percentage sand	14	15	9	na
Percentage vegetated	62	56	61	na
1993 population	113,326	296,532	208,797	109.9 million
Population per km² in 1993	582	578	549	763
Percentage increase, 1981-93	+27	+18	-15	+26
Cultivable land per capita (ha) in 1993	0.11	0.10	0.11	0.09
% permanently in-migrating in 1992	1.5	4.1	2.9	na
% seasonally out-migrating in 1992	0.2	0.9	2.1	na
% mauzas with primary school	37	53	61	74
% mauzas with high school	9	20	26	13
% mauzas with health facility†	9	15	24	4
% households mainly farming	46	41	43	na
% households mainly fishing	8	8	6	na
Cropping Intensity	185	186	166	172
Cattle per household	0.73	0.64	0.51	1.33
Households per mechanized boat	129	101	64	na
1988 flood deaths per 100,000	92	35	9	1.4
1988 % area flooded	100	100	100	46
1989-92 mean % area flooded	45	71	56	na
1988 mean flood duration (days)	42	37	44	na
1989-92 mean flood duration (days)	18	31	32	na
% houses flooded in 1988	100	100	94	na
mean % houses flooded in 1989-92	3	4	1	na
% houses destroyed in 1988	51	32	9	na
mean % houses destroyed in 1989-92	1	1	0	na

Source: FAP 16/19 inventory and satellite image analysis

*BBS (1993), except flood data, which is from Rogers, *et al.* (1989). Population figures are for 1991. Comparisons are for rural Bangladesh.

†Facilities below the union health center level, such as private doctors, may have been included in the inventory.

where more than 11 percent of inhabitants had moved in the previous year. Seasonal in- and out-migration were both more common in unprotected mainland than in island chars. In the middle reach, people move to island chars to cultivate and raise livestock during the dry season and leave when the land is flooded. Out-migration from the middle reach mainland is high, however, probably due to movement to find work in urban areas—communications to Dhaka and Faridpur are good from this reach.

6.4 Resource Base

Based on analysis of January 1993 Landsat imagery, the study area covered about 108,000 ha; of this, 28 percent was water, 13 percent was sand, and 59 percent was cultivated or vegetated. Within the banklines, 74 percent of the area was either sand or water and only 26 percent was vegetated or cultivated. The area of vegetated (productive) island chars increased more than proportionally with the widening of the river, increasing by about 9,000 ha (or more than doubling) between 1984 and 1993.

The resource base of the Padma charlands is dominated by farming: 43 percent of households cultivate land for a living and 30 percent depend on predominantly agricultural day labor. The Padma is an important riverine fishery, although much less so than the Meghna, and 8 percent of households fish as a primary occupation; for another 11 percent fishing is a secondary source of income. In the island chars, where 40 percent of households earn an income from fishing in at least part of the year, fishing is almost as important as agriculture.

The availability of cultivable land in the Padma charlands is similar to the national average (0.10 ha per capita compared with 0.09 ha for the nation), and on the mainland there is only 0.08 ha per capita. The majority of mauza land areas are reported to be cultivated. Cropping intensity averages 178 percent, but it is 162 percent in the island chars. Sandy land is concentrated in the island chars (60 percent sand), and is more common in the upper reach than in the lower. Dryland crops, mainly groundnuts, are more common in the island and attached chars, otherwise a wide variety of winter crops are grown.

Broadcast aus (early monsoon paddy) is most common throughout the area, but in the upper reach, B. aman is equally important. Aus and B. aman appear to be damaged by floods on average two to three times in 10 years, but are more vulnerable in the upper reach (damaged four times in 10 years). Transplanted aman, although offering higher yields, is vulnerable to flooding and virtually absent from the area. Local boro (winter-sown paddy) is quite widely grown on low land throughout the study area. In the mainland areas, particularly in the lower reach, some areas are irrigated and HYV boro is also grown, but monsoon flooding prevents the growing of a second crop in these areas. Despite the abundant supply of water, there is little if any irrigated land in the chars.

Numbers of cattle and buffaloes in the Padma charlands are lower (only 0.61 per household) than in Bangladesh as a whole, and may have been under-recorded. Numbers of goats and sheep are also lower than average. Livestock fattening on the abundant dry season grazing and crop residues is limited. Extensive deep monsoon flooding appears to constrain livestock numbers.

6.5 Flood Hazard

In 1987, 71 percent of cultivated land in the Padma study area was reported to have been flooded. In 1988, 100 percent was reported to have been flooded and flooding lasted an average of 40 days. By comparison, the average for 1989-92 "normal" monsoon conditions is 60 percent of land flooded for an average of 28 days. There was a trend toward less extensive and shorter-duration flooding in normal monsoon conditions in the upper reach compared with the middle and lower reaches; island chars also appear to be flooded more in normal years, but in 1988 there was no difference between reaches or land types.

The 1988 flood was estimated to be about a 1-in-60-year event in the Padma. In that year, 98 percent of houses in the Padma charlands were flooded and 31 percent destroyed. More were destroyed in the upper reach, and few in the lower reach. On average, only 3 percent of houses were flooded in each year during the 1989-92 period. Only in 1988 were there a substantial number of flood-related deaths: about 220 people were killed, particularly in the upper reach and island chars of the middle reach. Epidemic diseases were reported to have killed more people during the period 1988-92, particularly in the areas that reported the most flood deaths.

6.6 Services and Infrastructure

The provision of services and infrastructure is the key to improving the lives of char people given the hazards with which they live. In the Padma charlands, coverage by health workers is comparatively good, and there are a reasonable number of health care facilities, although they are concentrated in the unprotectd mainland and are distant from many of the island char people. Most people normally drink tubewell water, but in the 1988 flood, 74 percent of households reportedly drank river water, seriously compromising their health, and the island chars were worst affected.

Only 51 percent of inhabited mauzas have a primary school—more than 20 percent lower than the national average—and the chars have the fewest schools. There are 70 percent more children per primary school in the Padma charlands than in Bangladesh as a whole. Moreover, access to high schools is difficult for island char children.

Access problems limit the use of both health and education facilities, and river transport is also vital for coping with floods and erosion in the island chars. Local boat transport is entirely within the private sector, and mechanized boats have come to play an important role in linking the chars with such mainland facilities as markets. Mechanized boats are fairly numerous in the Padma, especially in the island chars (about 32 households per boat) compared with the unprotected mainland (about 148 per boat). Yet flooding and erosion could mean that a whole village would need to evacuate by boat in a short time. There are an average of nine households per non-mechanized boat throughout the area, but small boats are hazardous during peak floods.

6.7 Future Changes and Interventions

There are 618,000 people living in the Padma charlands who will continue to be at risk from flooding. At present, flood risk is greatest in the upper reach of the river, which experiences more extensive flooding for longer durations every year. The upper and middle reaches were worst affected in the 1988 flood. Flood modelling by FAP 25 indicates that embankments along the Padma, and upstream on the Jamuna would have little effect in a normal year. Modelling of the effect of these embankments in combination with the proposed Jamuna Bridge, however, indicates a rise in the level in a 1988 magnitude flood by about 30 cm along the Padma (FAP 25, 1993). This is the same increase in peak water level as was experienced along the Padma between the 1987 and 1988 flood peaks. The 1988 flood resulted in 23,000 Padma charland houses flooded to the roof (compared with 2,300 in 1987) and 35,000 destroyed (compared with 9,200 in 1987). An additional 30 cm of flooding likely would result in at least a comparable increase in damages.

Many char people are also at risk from erosion. Bank erosion has displaced many people who are presumed to have left the Padma charlands in the past decade, and there is no reason to believe that the next decade will be any different. It would appear that the active floodplain of the Padma is, even after 150 years, narrower than expected for a river of its magnitude and sediment load. Further widening can therefore be expected. Continual erosion will increase the population pressure both on the remaining charlands and in the rest of the country. The scope for river training works may be limited, unless a more predictable meander system can be stabilized, but even under such

conditions such works are likely to be hazardous. With the area of island chars rapidly increasing, measures to stabilize and prolong the lives of island chars might create more land. The trade-off is that it will be less productive and more hazardous than the mainland that is lost.

Chapter 7

MEGHNA SUMMARY

7.1 Study Area

The Meghna study area, which includes the whole Padma confluence, is partly bounded by embankments along the east bank of the confluence and Lower Meghna. On the west bank of the Upper Meghna the alignments of proposed embankments were used as the boundary. Where necessary, features flood-limiting features, such as roads, were used. The study extended in the Upper Meghna to the first narrowing of the river into a single channel. The southern limit, which is also the northern limit of the main cyclone risk zone, was the southernmost boundary of Hizla Thana.

In the Upper Meghna, in addition to the charland categories used in the other rivers, there are old, established islands separated from the mainland by secondary river channels; these have been termed "detached mainland" in this study.

Before about 1780, the Upper Meghna was the main channel for the Brahmaputra flow (catchment of 590,000 km^2), but since the Brahmaputra's diversion into the Jamuna, the catchment of the Upper Meghna has been reduced to the Sylhet Basin and the Old Brahmaputra (catchment of 80,000 km^2). Almost half of the Meghna's catchment lies within Bangladesh, but it includes the hills adjoining the Sylhet Basin, which have the highest annual rainfall in the world. Its dominant discharge is about 9,000 cumecs. The upper reach of the river has been stable since about 1800 in comparison with the lower reach.

The Lower Meghna, a highly dynamic system, receives the combined flow of the Padma and Upper Meghna and has a tidal regime. Since it carries the flow of the Padma, it has a total catchment of some 1.7 million km^2 (the combined catchments of the Brahmaputra and Ganges). The Lower Meghna, like the other rivers in Bangladesh carries a very heavy sediment load. The highest estimates put it at an average of one billion m^3 per year (FAP 4, 1993). This wandering river is characterized by unstable banklines and rapid rates of lateral movement. The pattern of channels and chars in the Meghna confluence and lower reach changes annually in response to the year's sequence of flows.

Flow in the Lower Meghna is characteristically high from June through September—the result of Himalayan snowmelt and monsoon rains—and very low in the winter. Annual flood peaks are on the order of 100,000 cumecs, five times the peak flow of the Mississippi (Coleman, 1968), and may exceed 160,000 cumecs in a 100-year return period flood (FAP 4, 1993).

The strong inflow of the Padma's discharge from the west has created in the Lower Meghna a historical tendency for eastward erosion, particularly in the large bend at the confluence of the two rivers. Analysis of dry season satellite images from 1984 and 1993, however, shows that the Lower Meghna has widened due to rapid west bank erosion. Since 1984, the centerline of the Lower Meghna has shifted west an average of 121 m per year, while the Upper Meghna has hardly moved.

In the confluence, the channel has widened from an average of 8 km in 1984 to 9 km in 1993, and

in the lower reach from 5.7 km to 8.8 km. This means that over a nine-year period the Lower Meghna widened an average of 339 m per year. The west bank has eroded at an average of more than 290 m per year between 1984 and 1993, and the east bank has eroded about 47 m per year. This indicates prolonged, rapid—even "catastrophic"—bank erosion in the lower reach compared with analysis of erosion rates over a 19-year period on the Jamuna, where such rapid erosion rates rarely persist for more than four or five years.

7.3 Population and River Dynamics

Tables 7.1, 7.2, and 7.3 summarize some of the most important inventory data by land type and reach. The inventory estimates the total 1993 study area population to have been 1.17 million, of which 320,000 lived in mauzas covering the 54 existing island chars. The attached char population was 260,000, there were 170,000 living on the detached mainland (islands), and there were 410,000 people on unprotected mainland, including setback land. Between 1981 and 1993 the total charland population grew by 20 percent, but within this period there were major shifts in the distribution of people due to bank erosion. Between 1984 and 1993 just under 20,000 ha of mainland eroded, and only 1,300 ha accreted, a net loss of 15 percent of the study area mainland. This eroded mainland was estimated to have supported about 140,000 people in 1984. Therefore, bank erosion must have forced 13 percent of the 1984 study area population to move between 1984 and 1993. This erosion mainly affected people in the Meghna-Padma confluence and the Lower Meghna.

Population displacement in the Upper Meghna was localized, and there was rapid growth in the population on the island chars, which may have accommodated some erosion victims. In the confluence and Lower Meghna, population has declined within the 1984 banklines. Although 4,000 ha of new charland accreted in the Lower Meghna between 1984 and 1993 the area lost to bank erosion exceeds that amount. Moreover, the new land is very low and can only be occupied in the dry season. The dynamism of the confluence char complex in this period has resulted in considerable movement of people within the chars, and limited the ability of the area to absorb displaced mainland people. Instead, there has been very rapid population growth since 1981 in the east bank mainland mauzas, particularly in the lower reach (from 351 people per km^2 in 1981 to 1,111 people per km^2 in 1993), and char people are thought to have settled in this unprotected mainland. Even so, the figures suggest that about 57 percent of lower reach erosion victims and all the confluence erosion victims, a total of some 120,000 people, have moved out of the Meghna charlands.

It is impossible to make erosion rate predictions for the Meghna based on a comparison of images covering only nine years. If the east bank is stabilized at Chandpur, however, it has been suggested that the present trend for rapid west bank erosion downstream of that point would continue, deflecting the flow into west bank offtake channels. In the longer term the bend in the confluence north of Chandpur, where the huge discharge of the Padma is turned from flowing east to south, is likely to continue eroding eastward until more resistant sediments are reached east of Chandpur.

Future erosion is clearly a threat to the mainland settlements by the confluence and Lower Meghna, but for the 238,000 people living on mid-channel chars in the confluence and Lower Meghna it is an ever-present danger. The inventory compiled data on homestead erosion in all areas, including the island chars. Even in the Upper Meghna much homestead erosion was reported in the period 1987-92 (over 50 percent of all homesteads reportedly eroded), reflecting the high population density in this area. The reports indicate that about 15 percent of households in the Meghna study area were displaced by erosion of some kind between 1987 and 1992.

In 1992, less than 2 percent of households migrated out of their mauzas, although there were locally higher rates, particularly in the lower west bank.

Table 7.1 Qualitative Summary of Differences between Reaches - Meghna

Characteristic	Upper Meghna	Confluence	Lower Meghna
Land	Sand in small area of chars, large area of detached mainland, 76% vegetated.	Most of sand in study area and water, 60% vegetated.	Little sand, 47% water, large island char on west side of main channel.
Population	Highest density, average 1,005 per km^2 in 1993 and growth greater than national average since 1981.	Moderate density (612 per km^2). Locally high population on east bank mainland, low on west bank south of Padma, but low growth overall.	Lowest density, 312 per km^2. Growth much lower than national average since 1981 on west bank and island chars (eroding). Higher on east bank.
Erosion Pattern	Small areas eroding slowly and steadily, but densely populated.	Widening results in erosion of densely populated mainland. Much erosion and accretion of island chars.	Rapid west bank erosion in past decade; few mid-channel chars to erode.
Migration in 1992	Very little migration of any type reported (under 1% households involved), consistent with stable environment.	High incidence permanent in-migration (9% of 1993 households came in 1992) due to rapid changes in island char complex where 26% are in-migrants.	High seasonal in- and out-migration in Hizla island char linked with seasonal demand for farm labor, and in new low-lying chars only cultivated in dry season.
Infrastructure	Good provision of primary and high school and health facilities. Access constrained by river channels.	Good primary and high school and health facility provision.	Poor provision of primary and high school and health facilities in all land types (inhabited mauzas only).
Occupations	54% households cultivate own land, 14% mainly fish.	High percentage fishing on island chars.	High percentage (34%) fishermen in all land types.
Agriculture	Diverse, HYV boro and B aman important.	B aus + aman and wide range of rabi crops.	L & HYV boro and T aman important in island char.
Livestock	High livestock numbers compared to land area and human population.	Moderate numbers.	Lowest numbers relative to land and human population, higher in island chars.
Boats	More mechanized boats relative to people.	Lowest numbers in Meghna, in attached chars.	About 68 households per mechanized boat.
Deaths	Concentrations of flood and disease deaths.	Lowest incidence of hazard-caused deaths.	Most flood deaths, particularly in attached chars.
Floods	Normal floods longer and more extensive than other reaches, high incidence of house damage in 1987 and 1988.	Extent as in upper reach but duration less in normal and peak floods, 98% houses flooded in 1988 but only 32% in 1987.	Normal floods much shorter duration, less impact in 1987 and 1988 floods when fewer houses flooded (37% in 1988), lowest damage.

Source: FAP 16 Charland Inventory

Table 7.2 Summary of Mauza Inventory Data by Char Land Type - Meghna

Parameter	Island Char	Attached Char	Detached Mainland	Unprotected Mainland	Bangladesh*
Area (ha)	89,736	51,039	14,133	40,753	14.4 million
Percentage water	39	29	7	24	na
Percentage sand	5	2	1	1	na
Percentage vegetated	56	69	92	75	na
1993 population	325,485	260,635	169,248	410,419	109.9 million
Population per km^2 in 1993	363	511	1,198	1,007	763
Percentage increase, 1981-93	+33	-3	+31	+25	+26
Cultivable land per capita (ha) in 1993	0.12	0.13	0.08	0.07	0.09
% permanently out-migrating in 1992	2.0	2.0	0.2	1.7	na
% seasonally in-migrating in 1992	6.1	2.5	0.0	1.0	na
% mauzas with primary school	47	64	65	54	74
% mauzas with high school	6	19	14	16	13
% mauzas with health facility†	6	9	14	17	4
% households mainly farming	45	44	54	43	na
% households mainly fishing	22	21	11	19	na
Cropping Intensity	147	143	147	159	172
Cattle per household	0.74	0.56	1.09	0.70	1.33
Households per mechanized boat	43	63	64	66	na
1988 flood deaths per 100,000	50	64	59	57	1.4
1988 % area flooded	57	99	100	99	46
1989-92 % area flooded	39	68	57	64	na
1988 mean flood duration (days)	42	60	41	74	na
1989-92 mean flood duration (days)	28	40	14	51	na
% houses flooded in 1988	54	95	97	95	na
% houses flooded in 1989-92	6	11	2	14	na
% houses destroyed in 1988	26	38	50	33	na
% houses destroyed in 1989-92	1	2	1	3	na

Source: FAP 16/19 inventory and satellite image analysis

*BBS (1993), except flood data, which is from Rogers, *et al.* (1989). Population figures are for 1991. Comparisons are for rural Bangladesh.

†Facilities below the union health center level, such as private doctors, may have been included in the inventory.

Table 7.3 Summary of Mauza Inventory Data by Reach - Meghna

Parameter	Upper Reach	Confluence	Lower Reach	Bangladesh*
Area (ha)	50,572	68,294	76,794	14.4 million
Percentage water	22	34	47	na
Percentage sand	2	6	1	na
Percentage vegetated	76	60	52	na
1993 population	508,031	418,055	239,701	109.9 million
Population per km^2 in 1993	1,027	665	363	763
Percentage increase, 1981-93	+34	+15	+6	+26
Cultivable land per capita (ha) in 1993	0.08	0.10	0.17	0.09
% permanently out-migrating in 1992	0.6	2.3	2.3	na
% seasonally in-migrating in 1992	0.5	3.2	4.5	na
% mauzas with primary school	58	61	46	74
% mauzas with high school	14	17	8	13
% mauzas with health facility†	13	12	7	4
% households mainly farming	52	42	40	na
% households mainly fishing	14	15	34	na
Cropping Intensity	155	145	150	172
Cattle per household	0.92	0.63	0.58	1.33
Households per mechanized boat	47	69	68	na
1988 flood deaths per 100,000	73	26	77	1.4
1988 % area flooded	100	99	61	46
1989-92 % area flooded	68	61	41	na
1988 mean flood duration (days)	86	40	16	na
1989-92 mean flood duration (days)	28	40	14	na
% houses flooded in 1988	97	98	37	na
% houses flooded in 1989-92	7	8	14	na
% houses destroyed in 1988	41	37	20	na
% houses destroyed in 1989-92	1	1	5	na

Source: FAP 16/19 inventory and satellite image analysis

*BBS (1993), except flood data, which is from Rogers, *et al.* (1989). Population figures are for 1991. Comparisons are for rural Bangladesh.

†Facilities below the union health center level, such as private doctors, may have been included in the inventory.

On the other hand, 4 percent of households in the study area in 1993 had moved into their mauza in the previous year, mainly to colonize accreting island chars, particularly in the confluence and lower reach. Seasonal in- and out-migration were both common in the island chars. This apparently is an adjustment to the hydrologic cycle, whereby people move into island chars and attached chars to cultivate, raise livestock, and meet seasonal labor demand during the dry season and leave when the land is flooded.

7.4 Resource Base

Based on analysis of March 1993 Landsat imagery, the Meghna study area covered about 196,000 ha of land; of this, 36 percent was water, 3 percent was sand, and 61 percent was cultivated or vegetated. Within the banklines, 74 percent of the area was either sand or water and only 26 percent was vegetated or cultivated. The area of vegetated (productive) island chars increased more or less in proportion with the widening of the river, increasing by about 6,500 ha between 1984 and 1993.

The resource base of the Meghna charlands is dominated by farming: 45 percent of households cultivate land for a living and 23 percent depend on day labor, which is predominantly agricultural. The Meghna is the main riverine fishery in Bangladesh, and 19 percent of households fish as a primary occupation, and for another 16 percent fishing is a secondary source of income. In the lower reach, fishing is almost as important as agriculture for the charland economy.

The availability of cultivable land in the Meghna charlands is similar to the national average (0.10 ha per capita compared with 0.09 ha for the nation), and on the mainland there is only 0.07 ha per capita. About 80 percent of mauza land areas are reported to be cultivated. Cropping intensity averages 150 percent and is lower in the chars than the mainland, particularly in the confluence island chars. There is slightly more sandy land in the Upper Meghna channel, and dry-land crops, mainly groundnuts and sweet potatoes, are more common in the island chars of this reach, otherwise a wide variety of winter crops are grown.

Broadcast aman (monsoon season paddy), which is tolerant of deep water, is most common in the upper reach, where flooding is deep and prolonged. Aus and B. aman appear to be damaged by floods on average three times in 10 years. Transplanted aman, although offering higher yields, is vulnerable to flooding and mainly grown in the lower reach around the island of Hizla, which is largely flood-free. Local boro (winter-sown paddy) is widely grown on low land in the island chars. In the island char of Hizla, where irrigation is apparently available, HYV boro is also grown. Despite the abundant supply of water, there is otherwise only a moderate area of irrigated land in the chars.

Numbers of cattle and buffaloes in the Meghna charlands are lower (only 0.73 per household) than in Bangladesh as a whole, as are numbers of goats and sheep. In some areas of the upper reach and confluence livestock are fattened commercially on the abundant dry season grazing and crop residues. Extensive deep monsoon flooding appears to constrain livestock numbers.

7.5 Flood Hazard

In 1987, more than 70 percent of cultivated land in the Meghna study area was reportedly flooded. In 1988, 87 percent was flooded for an average of 56 days. By comparison, the average for 1989-92 "normal" monsoon conditions is 57 percent of land flooded for an average of 37 days. There was a strong trend toward more extensive and longer-duration flooding in the north and less extensive in the south, and in 1988 durations fell from 86 to 16 days between the upper and lower reaches.

The 1988 flood was estimated to be about a 1-in-30-year event in the Meghna. In that year, 82 percent of houses in the Meghna charlands were flooded and 34 percent destroyed. Fewer were affected in the Lower Meghna island of Hizla. On average, only 9 percent of houses were flooded in each year during the 1989-92 period. Only in 1988

were there a substantial number of flood-related deaths: more than 660 people were killed, particularly in the upper reach. Epidemic diseases were reported to have killed more people during the period 1988-92, particularly in the island chars of the upper and middle reaches.

7.6 Services and Infrastructure

Study area health care facilities are concentrated in the detached and unprotected mainland. While coverage by health workers is comparatively good, there are fewer health care facilities than in other areas, particularly in the lower reach, and they are far from many char people. Most people normally drink tubewell water, but in the 1988 flood, 70 percent of households drank river water, seriously compromising their health. Only 55 percent of inhabited mauzas have a primary school, almost 20 percent lower than the national average, and island chars have the fewest schools. There are 54 percent more children per high school in the charlands than in Bangladesh as a whole, and such schools are rare in island chars.

Access problems limit the use of both health and education facilities, and river transport is vital for coping with floods and erosion in the island chars. Local boat transport is entirely within the private sector, and mechanized boats have come to play an important role in linking the chars with such mainland facilities as markets. Mechanized boats are fairly numerous in the Meghna, especially in the island chars (about 43 households per boat), compared with the unprotected mainland (about 66 per boat). Yet flooding and erosion could mean that a whole village would need to evacuate by boat in a short time. There are an average of 8 households per non-mechanized boat throughout the area, but such small boats are hazardous during peak floods.

7.7 Future Changes and Interventions

There are 1.17 million people living in the Meghna charlands who will continue to be at risk from flooding. At present, flood risk is greatest in the upper reach of the river, which experiences more extensive flooding for longer durations every year. The upper and confluence reaches were worst affected in the 1988 flood. Flood modelling by FAP 25 indicates that there would be little impact from embankment improvements on the other main rivers. Even with the Upper Meghna fully embanked, normal monsoon water levels would fall (runoff from the adjacent floodplain would be retained by embankments), and only at Chandpur is an increase in water level predicted for a 1988-magnitude flood (similar to the normal monsoon water level increase following a 35 cm increase in sea level). While the Meghna char people are likely to face the same flood risks in the future, they would still benefit from measures to help them cope.

Bank erosion has displaced many people who are presumed to have left the Meghna charlands in the past decade, and there is no reason to believe that the next decade will be any different. In particular, the change of direction in the bulk of the flow from eastward in the Padma to southward in the Meghna results in fluctuating waves of erosion along the east bank in the confluence as the main channel shifts location. Continual erosion will increase population pressure both on the remaining charlands and in the rest of the country. River training works may be a viable way to stem this loss of land and consequent population displacement, particularly in the Upper Meghna where there are very high population densities and slow erosion. In the Lower Meghna, the impacts on river morphology are uncertain. Measures to stabilize and prolong the lives of island chars could also benefit the 320,000 people living on them.

Chapter 8

FLOOD RESPONSE

8.1 Vulnerability to Flood Hazards

Char people are vulnerable to several hazards, of which flood is only one. Violent storms called "nor'westers" can wreak havoc on fragile grass houses in the pre-monsoon season. In most places, diseases associated with the normal monsoon cycle are reported to be a greater cause of death than floods. This section, however, will focus on char people's experience with annual inundation and severe flood. Table 8.1 shows that this hazard is very extensive, affecting most of the charland areas in a severe year.

Riverine islands and nearby unprotected mainland areas have large percentages of low agricultural lands that are regularly inundated in the annual monsoon; this is an expected occurrence. The inventory found, for example, that some 57 percent of cultivable land in the Meghna is underwater in the monsoon season; and in the Padma, 60 percent is awash (average percentages for four monsoons 1989-92). In the Ganges, where the charlands are between embankments for much of their length, 70 percent of cultivable charland was underwater in the monsoon.

The Brahmaputra-Jamuna inventory found variable average flooding from north to south: in 1991, considered a "high-average" year, about 65 percent of the total land area was inundated in the upper reach, but only 33 percent was inundated in

Table 8.1 Area and Duration of Flooding in Charland Survey Areas

Location	Brahmaputra-Jamuna		Ganges		Padma		Meghna		Bangladesh Average
	Area (%)	Duration (days)	Area (%)	Duration (days)	Area (%)	Duration (days)	Area (%)	Duration (days)	Area (%)
1988 FLOOD									
Island Char	91	22	100	44	100	41	57	42	46
Attached Char	84	23	98	38	100	46	99	60	46
Unprotected Mainland	93	28	99	37	100	39	100	41-74	46
1991 FLOOD									
Island Char	58	12	83	26	72	33	39	28	NA
Attached Char	52	13	65	21	47	24	68	40	NA
Unprotected Mainland	33	11	69	19	61	27	64	51	NA

the lower reach; similar variations were found in all four rivers covered by the survey.

The impact of severe floods on charland agriculture is determined by (1) the percentage of high, medium, and low lands cultivated, (2) the extent of double or triple cropping, (3) the duration of flooding, and (4) the rate of rise of floodwater. Items (1) and (2) are interrelated and reflect the "normal" or expected peak monsoon water levels.

The Charland Study made no overall comparison of char height between river reaches, but in the six RRA areas the majority of agricultural lands were low lands. The percentages ranged from 10 to 90 percent: the area of low land on the Ganges was 50 percent, in the upper Jamuna and Meghna confluence, 60 percent, in the middle Jamuna, 80 percent, and in the Padma, 90 percent.[1] All areas visited had some mauzas with double- or triple-cropped land, indicating some degree of agricultural vulnerability to floods in all char areas.

8.2 Severe Flood Impacts

8.2.1 Extent of Floods

The extent and duration of severe floods, such as those of 1987 and 1988, were especially significant in most charlands, although the impact of these events on the chars of each river also differed from reach to reach. In 1988, Meghna island and attached chars were almost 100 percent flooded for 40 to 60 days, and unprotected mainland areas for an average of 74 days. In the lower Meghna, however, the waters broaden as they approach the delta, and charlands in this area were less severely affected than in the upper Meghna and confluence areas. Each river showed a similarly dramatic increase over normal inundation levels in 1988 for most reaches, with more than 85 percent of all cultivable land flooded in 1988, implying increases in the area flooded over the 1989-92 average of 13-50 percent.

In 1988, average peak flood duration for the Jamuna was 24 days; for the Ganges, 27 days; for the Padma, 38 days; and for the Meghna, 56 days. The increment in flood duration in 1988 was up to twice the 1991 duration (Jamuna, Table 8.1).

Sand carpeting is a common annual problem for many char farmers, even those who consider normal inundation mostly benign. The RRA team encountered many whose agricultural lands were ruined in one season, forcing a change of occupation at least until some other development might reverse their bad fortune.

8.2.2 Homestead Flooding

People build homesteads on the highest available land and (if they stay for any length of time in a place) further elevate their dwellings on built-up plinths to avoid annual inundation. Unlike on the mainland, however, many char people expect to have their homes flooded each year despite these measures, creating inconvenience for people and some danger for animals. So it can be said that, if water entering the homestead is a sign of a flood *crisis*, such events are far more common in charlands than in the mainland.

The inventory of the Brahmaputra-Jamuna did not collect data on houses flooded, but this was covered in the flood proofing study sample surveys. Table 8.2 shows that in the other three rivers the majority of houses were flooded in 1988 (almost double the Bangladesh average), and about a third of houses were reported destroyed. This compares with averages of under 5 percent flooded in all but the Meghna in 1989-92. In the two reaches of the Brahmaputra-Jamuna where sample surveys were done, 90 to 97 percent of houses were flooded in 1988, compared with 37 percent in the upper reach (Kurigram) and 26 percent in the lower (north) reach of Bhuapur in 1991. Island chars were no worse affected than unprotected mainland.

The number of households in 1988 is unknown, but the data imply that in 1992-93 the number of households with houses destroyed in a 1988 magnitude flood would have been about 52,800 in the Meghna; in the Ganges, 32,900; and in the Padma, 34,300.

Table 8.2 Housing Flooded and Destroyed*

Location	Ganges		Padma		Meghna	
	Flooded (%)	Destroyed (%)	Flooded (%)	Destroyed (%)	Flooded (%)	Destroyed (%)
1988 FLOOD						
Island Char	88	33	100	40	54	26
Attached Char	84	23	96	50	95	38
Unprotected Mainland	86	27	98	24	97	33
1989-1992						
Island Char	4	1	4	1	6	1
Attached Char	3	0	3	1	11	2
Unprotected Mainland	2	0	3	1	14	3

*Questions added after first phase of survey in Brahmaputra-Jamuna, covered in sample surveys as part of the flood proofing survey.

The flood proofing surveys found that in 1988 island char houses were flooded more deeply than unprotected mainland houses in both Kurigram and Bhuapur. In Kurigram, 57 percent of people evacuated, and in Bhuapur 35 percent did so, but 72 percent of Kurigram cattle and 55 percent of Bhuapur cattle were moved because of the flood. The majority of households experiencing in-house flood depths of 1 m or more were found to have moved out. Average flood losses per household in Bhuapur were Tk. 7,581 (80 percent confidence interval, Tk. 5,980-9,180), and in Kurigram, Tk. 5,300 (80 percent confidence interval, Tk. 4,730-5,870). Losses depend to a considerable extent on the value of housing and immovable assets such as trees, and these are higher in more stable areas such as unprotected mainland.

If these losses were typical of the other reaches of the river, then the total losses to homesteads (fixed assets, evacuation costs, loss of livestock) in 1988 may have been Tk. 6,000 per household or Tk. 1,700 million in the Brahmaputra-Jamuna alone. The main components of which were housing, livestock, and tree damage. Crop losses were also reported to be substantial at about Tk. 13,000 per household in Bhuapur and Tk. 8,600 per household in Kurigram for the 1988 aus and aman seasons. These figures are averaged across all households in the sample areas (including nonfarm households), so agricultural losses may have been on the order of Tk. 3,000 million. Most households said they could do more to prevent damage, for example with better warnings or transport facilities, but that few of the 1988 losses were avoidable.

According to the inventory reports, flood-related deaths in 1988 were concentrated in the charlands, particularly in the Brahmaputra-Jamuna (Table 8.3). Consequently, 58 percent of reported deaths in the charlands were along the Brahmaputra-Jamuna, compared with a very low death rate reported in the Padma. The total flood-related deaths reported in the charlands appears to be more than the national totals reported for the 1988 floods. Unlike the cyclone-prone areas of the country, however, losses to property and livestock are generally of greater significance than human deaths in the riverine chars.

Table 8.3 1988 Flood-Related Deaths in the Charland Survey Areas

Location	Brahmaputra-Jamuna	Ganges	Padma	Meghna		
	TOTAL DEATHS				Total Number	% of Total
Island Char	416	6	6	36	463	21.4
Attached Char	330	141	32	167	670	30.9
Unprotected Mainland	512	144	42	336	1,034	47.7
Total by River	1,257	291	81	539	2,168	100
Percent of Total	58.0	13.4	3.7	24.9	100	
	DEATHS PER 100,000 POPULATION				Bangladesh Average	
Island Char	81	11	11	11	1.4	
Attached Char	81	100	35	64	1.4	
Unprotected Mainland	57	29	9	58	1.4	

8.2.3 Flood Coping Measures

In RRA interviews, people explained to team members how they prepare for and cope with either normal monsoon inundation or severe floods. In most homesteads, grains and other valuables are stored on platforms (*machas*), whereas mainland people only build such structures if they anticipate special flood problems. People try to anticipate the extent of inundation as the monsoon approaches mainly by listening to the radio; but few said this was an adequate source of information, and many said they could cope more successfully if they had more time to plan for specific rises in river water levels predicted for local reference points.

One widespread pattern of flood preparation with serious negative economic consequences is the sale of cattle and other large animals at low prices before the monsoon season. This measure was described in all areas as one way to salvage some part of the investment in animals rather than risk losing them to disease and starvation, possibilities anticipated even in normal inundation conditions, when settlements and grazing lands may be underwater.

When inundation or flood occurs, people may also choose to move with their animals to higher land, often the nearest BWDB embankment. In Kurigram and Bhuapur, 75-80 percent of households moved their livestock, but the island char people moved their stock for a month (more than twice as long as mainlanders). If they remain at home, many have problems caring for large animals, which may have to stand in water for some time, or be unable to lie down because of the water that surrounds them, when that occurs the animals become fatigued and vulnerable to diseases. Poultry are vulnerable to drowning in floods, just as they are on the mainland.

Problems people mentioned in coping with floods are similar to those in the mainland but they are more intense and possibly annual events in chars. These include difficulties obtaining food and supplies, difficulty cooking, and problems in

Table 8.4 Predicted Increase in Water in a Repeat 1988 Flood Under Three Scenarios

River/RRA	Gauging Station	Increase (cm)		
		Scenario 2	Scenario 3	Scenario 5
Upper Jamuna	Bahadurabad	8	9	9
Middle Jamuna	Sirajganj	55	83	87
Ganges	Hardinge Bridge	0	0	6
Padma	Mawa	17	17	34
Upper Meghna	Baidyer Bazar	-8	-8	3
Meghna Confluence	Chandpur	6	6	17

Source: FAP 25
Scenario 2 = Jamuna-Dhaleswari left embankment
Scenario 3 = Scenario 2 plus Jamuna Bridge
Scenario 5 = Maximum embankment development

traveling and finding work. Access to medical care is especially problematic. One Ganges char woman, in describing the differences between char and mainland life said, "The worst thing about char life is women dying in childbirth because they cannot get medical attention during floods". Privacy for sanitation purposes (urination, defecation) is a problem for everyone, but especially for women. Health dangers from drinking contaminated river water are prevalent during the monsoon season and almost universal during severe floods, when most tubewells are submerged.

8.3 Perceived Associations Between Flood and Erosion

Although few people interviewed by the RRA teams see a direct connection between flood and erosion, the monsoon season is a transition point in char life, when many people are waiting to see how their land survives, i.e., whether they will have to move or not. It is the key decision point in the annual cycle. Many people explained, for example, that they would not invest much effort or money in building up their homesteads until after the monsoon season, when they would know whether their island was still there.

8.4 Future Flood Risks

Attention under FAP has been drawn to the possibility that embankments to protect mainland areas will raise flood levels in the charlands by restricting flood flow. FAP 25 (1993) modelled floods of 1986, 1987, and 1988 magnitude for the main rivers with seven different combinations of main river embankments, plus sea level rise, and construction of the Jamuna Bridge. The results of this study were essentially that the greatest effects would be on the Jamuna, and to some extent the Padma (and lesser rivers outside the Charland Study), and that the greatest impact would be from the combination of the Jamuna Bridge and left bank Jamuna embankments, which would have a synergistic impact in raising peak flood levels.

Table 8.4 summarizes the predicted increases in water in a repeat of the 1988 flood under three of the FAP 25 scenarios. These results show that if all these works went ahead, some 1.77 million people living in the chars and unprotected mainland of the middle and lower reaches of the Jamuna and Padma could be flooded by an extra 30 to 80 cm of water (depending on char location) in a repeat of the 1988 flood. Even in a normal

flood (1986 conditions) in the Sirajganj area peak water levels would be 28 cm higher than without the bridge and left embankment.

While these increases in flood depth may not appear to be large, a 20 cm difference between the 1987 and 1988 flood peaks in the Padma accounted for an increase in the number of houses flooded to roof level from 2,300 to about 23,000, and in the number of houses destroyed from 9,200 to about 35,000. In the Jamuna, it was estimated that if the bridge and embankments are constructed that 186,200 people will live in areas where a 1988 flood would be 80 cm higher and 558,700 will live where that flood would be 50 cm higher. Therefore, many char people will be at greater risk from flooding as a result of measures to benefit mainland people unless steps are taken to mitigate these effects.

NOTES

1. These modes were affected by RRA teams' selection of places to visit, but they reflect a relatively consistent pattern.

Chapter 9

RECOMMENDATIONS

9.1 Objectives

The aim of the charland inventory and socioeconomic survey is to provide baseline data for development planning, and particularly, although not exclusively, for planning under the FAP. This report summarizes and compares the analyses of population, resources, and morphology data of the charlands of the Jamuna-Brahmaputra, Ganges, Padma, and Meghna rivers. It also incorporates, where appropriate, qualitative information gathered by the socioeconomic survey of the charlands.

There is clearly a dilemma over the long-term management strategy of Bangladesh's mighty rivers. Confining them to their current active channels through bank protection works and river training would be risky and cost billions. On the other hand, with such an intervention, the chronic loss of homes and livelihoods caused by erosion of the unprotected mainland may be halted.

Over the typical 50-year economic life of new infrastructure, more than 3 million people could benefit. Making an investment in new infrastructure would invariably lead to the permanent embankment of these rivers to the disbenefit of the current charland population of 4.2 million. Identifying the optimal soultion and agreeing on a strategy will be difficult.

The charland inventory and socioeconomic survey are but the first steps in achieving better understanding of the charlands and their populations. To accomplish this, the results of the work presented in the charland reports and summarized here should be built upon in the future.

9.2 Future Uses of the Charland GIS

9.2.1 Overall Future

The charland GIS needs to have a continued and stable life if other institutions and projects are to make use of the wealth of detailed data it contains. This report summarizes analysis of the satellite image and inventory analyses for the whole of the Jamuna-Brahmaputra, Ganges, Padma, and Meghna rivers within Bangladesh, but similar analysis would be possible for smaller planning areas within these study areas. To effectively achieve this the charland GIS will need to be operated, maintained, and updated by an organization that can work with studies inside and outside the FAP to identify the planning needs the GIS can meet. It must also be able to carry out detailed analysis and additional studies, and then produce tailored outputs for specific users. This need might be met by institutionalizing the capabilities of FAP 19 within an organization dedicated to planning and applied research on natural resource and hazard management.

Water resources development planning in the charlands of all four rivers falls between the boundaries of FAP regional studies. In the case of the Jamuna and Meghna, feasibility studies are expected to address impacts in adjacent char areas. In the Padma and Ganges, no such feasibility studies are

planned. In all cases, the charland GIS could be useful for planning projects along these rivers.

Below are some specific uses the GIS can be put to, others are addressed in the separate reports on each river.

9.2.2 Jamuna Multi-purpose Bridge

Approach roads for the Jamuna multi-purpose bridge are already under construction, an impact assessment and resettlement plan have been prepared. All the activities associated with the Jamuna bridge need baseline data, particularly for the upstream area where flood risks are expected to increase as a result of river confinement. The existing river morphology will need study, and a monitoring program will need to be established. The charland study provides a basis for this work. This could continue with remote sensing monitoring, which could be linked with hydraulic modelling by FAP 25 and the charland inventory to identify potential impacts, and so form a starting point for designing a program to mitigate the impacts of the bridge in the charlands.

9.2.3 Morphology Studies

The analysis of Chapter 2 has already shown that the riverine charlands of Bangladesh have changed considerably in the recent past (1984-1993), and indicated greater changes over the long term (1767-1984). Detailed analysis of morphological trends and erosion rates has been undertaken for the Jamuna, using a series of satellite images and relating these with banklines from the historic maps that have been registered to common coordinates. This work needs to be expanded to the other three rivers (Ganges, Padma, and Meghna).

9.2.4 Flood Proofing Programs

As a follow-up to FAP 23, a variety of pilot flood proofing interventions are being proposed for the Brahmaputra-Jamuna. The 1993 charland household sample interview surveys in Kurigram and Bhuapur areas of the Jamuna were designed to provide data and analysis that will aid the design of such projects. It is hoped that future flood proofing programs for the Jamuna could use a combination of the GIS and inventory data to identify broad problems and program priorities, then follow up with more detailed local surveys to tailor implementation to local needs.

In the Ganges and Padma charlands, flood risks are already high, and they are not expected to decrease. In the Padma, they may even increase as a consequence of proposed interventions in the Jamuna and if the Padma itself is further embanked. Although erosion risk is quite high in the dynamic island chars, islands may persist for longer than in the other rivers. This should be confirmed by analyzing a series of satellite images and, if found to be correct, small-scale flood proofing works should be considered as a means of counteracting changes in flood risk, and of improving the lives of char people in these two rivers even if flood risks are unchanged.

Although flood risks are unlikely to worsen in the Meghna charlands, this does not mean that flood proofing should ignore these areas. The Upper Meghna is more suitable than many charland areas for small-scale flood proofing works because it is relatively stable and embankments are not practical for the islands.

It is hoped that this report can act as a catalyst to encourage flood proofing and char development programs in all the rivers of Bangladesh, as FAP 3.1 has to integrated development in the middle Jamuna chars. FAP 3.1 has spurred the proposal of measures to enable char people to diversify and increase their incomes and so reduce vulnerability. Planning such interventions could use a combination of the GIS and inventory data to identify broad problems and program priorities. This would need to be followed up with more detailed local surveys and consultation to tailor implementation to local needs.

9.2.5 Local Government

Government services are limited in the chars, although the inventory shows that some services

are provided. The inventory can be used to identify areas reporting low service provision or no facilities relative to population, and to plan additional service. Additionally, detailed information from this study on past and future erosion and accretion patterns will be important in ensuring that appropriate services are provided without a high risk of infrastructure loss. The Local Government Engineering Department (LGED) is currently preparing updated maps for all thanas, which will be incorporated in a GIS. The infrastructure data in the LGED maps could be combined with hazard and resource data in the charland inventory and the image analysis of morphological changes to form an integrated planning tool.

9.2.6 NGOs

The inventory found a number of NGOs active in charlands, but they concentrate their efforts on the unprotected mainland. The inventory indicates that there are still many ways in which these NGOs could help char people improve their livelihoods and lower their vulnerability to flood and erosion impacts. NGOs active in the area could use the inventory data to identify priority issues and their locations and extent for planning their programs. If NGOs are to extend their activities in this way they will need information on hazard risks to avoid loss of expensive infrastructure.

9.3 The Uses of Socioeconomic Data

When working in riverine charlands there are a number of points to keep in mind about any group of potential program beneficiaries. This study has demonstrated that charlands are not all alike and the social structures of char people vary somewhat from people in the rest of Bangladesh. Char people therefore need to be understood within their own context. Such information will enable the planner to understand several factors likely to affect the outcome of planned activities. The following should be taken into consideration:

(1) Type of charland and stage of char development: attached, island (accreted or detached mainland) or mainland; new or old; cultivated, settled, or cultivated and settled; people's estimates of the char's stability.

(2) Settlement history: are the inhabitants a long-established local group or recent immigrants; what were their motives for settling; what ties do they have to other places; are there any local conflicts?

(3) Community composition and social structure: families (*gushti, sarik*) and societies (*samaj*) as well as the nature of their leadership; meaningful, long-term associations between people likely to remain interdependent; terms and conditions of land grants to destitute settlers (*uthuli* in Jamuna and Meghna). Nature of ties to union and thana officials.

(4) Type of Household: female-headed percentages, joint families able to take advantage of diversified employment options and pool resources.

(5) Typical erosion displacement experiences of the group: number and timing of moves; groups that have stayed together when moving; their ideas of problems caused by these experiences and current or future needs.

(6) Alternative occupational patterns: previous working experiences and concepts of primary, secondary, and temporary work possibilities for both men and women.

(7) Local skills in exploiting resources (lands, animals, natural vegetation, crops) that can serve as a basis for introducing new techniques or expanding income-generation programs.

(8) Main assets: animals, tools, cooking equipment—things needing protection in floods.

(9) Gender division of labor: normal work activities (current, previous, acceptable/unacceptable) of males and females of various ages.

(10) Perceptions of problems and needs; the honest reactions of char people to outsiders' ideas and plans for them.

The resource base of a community tends to be greater on more established land. Intense local conflicts will reduce the incentives to invest in productive activities even if programs are implemented to facilitate them. Likewise, control by large landlords who may evict tenants and erosion risk may make investments inappropriate.

9.4 Longer-Term Institutional Approaches

The riverine charland areas, particularly island and attached chars, appear to have been somewhat neglected, having rarely been the focus of government or NGO development programs. In part this reflects the highly mobile nature of charland resources and the population living on them. It is difficult for any administration with fixed boundaries to come to grips with something as temporary as charland. Under the FAP some official attention, in the form of studies, has now been given to riverine chars, and a national database on these diverse and complex areas has been compiled. This information needs to be properly used and taken into account by the full range of ministries and departments that could and should be actively involved in improving the livelihoods of char people.

This study of riverine charlands has clearly demonstrated that charland evolution and the associated shifting population and resource base can be successfully quantified and mapped. The next major task should be to extend this methodology into the more vulnerable coastal chars where, because of the risk from cyclones, the impacts of hazards are an order of magnitude greater than in the riverine chars.

While the charlands are covered by normal development activities, to the extent that these activities are suited to the chars, government programs suited to the unique needs of char people have yet to be devised and implemented. This might be done by a specific program or development board involving relevant agencies, which would have the advantage of promoting the more integrated and interdisciplinary approach that seems to be needed in the chars. Alternatively, it might be accomplished by ensuring that each agency, in its own planning and service provision, take note of the problems and needs of the char areas. The government will, as a first step, need continued interactive access to the charland GIS and database.

9.5 Specific Program Interventions

Some specific public programs could benefit large segments of the charland population covered by this study. The priority recommendations presented here are of five types: information resource development, flood and erosion assistance, basic services, economic development measures, and policy improvements. Some of these recommendations have been made elsewhere in slightly different forms.

9.5.1 Development of Information Resources

Baseline data on charland demographics and resources have been compiled in the inventories under the Charlands Study. These need to be updated periodically, combined with 1991 census data, and refined as development agencies and departments make use of the data for planning purposes. Using the inventory, strategies need to be developed that better utilize the resources available in the chars.

9.5.2 Flood and Erosion Assistance

Flood proofing a settlement, i.e., preparing it to withstand floods with minimum disruption of normal subsistence and social activities, is a complex subject that has been addressed by a special report of the Charlands Study. Ultimately it can be a vehicle to increase economic flexibility and protect resources, thus protecting vulnerable groups from disastrous losses at times of crisis. The study found that, in general, adjustments made by char people in terms of raising homesteads are appropriate given the high risk of erosion, and that flood shelters within the char areas offer limited benefits.

Within this context, some specific priority needs associated with normal inundation and floods were identified by RRA teams visiting several riverine char areas:

Improved flood warning is an urgent need in all char areas. Since some people have to make elaborate preparations, advance warning about water levels in specific areas would greatly enhance their capacity to prepare for floods. The main requirement is for meaningful warnings that relate to local features and flood levels. The most appropriate methods of information dissemination would be radio and local announcements over loudspeakers in marketplaces. Other priority needs can be most effectively used when combined with improved warnings.

Animal shelter is one of the most common problems char people have in normal inundation, and is even more important in severe floods. It is such a serious problem that people sell off large animals in anticipation of the rainy season rather than risk losing them to disease or starvation. Any public monsoon season arrangements to shelter animals more securely, feed them, and provide veterinary services would be of great interest to people in many char areas.

Human shelter facilities most used are public high places, especially BWDB embankments. Developing multi-purpose raised areas in charlands that could be used for basic services such as education and health care would make such facilities accessible. In many char areas this would mean risking investment loss within a short time because of erosion. But it would be appropriate where chars are stable (as in the Upper Meghna), or where the mainland is not threatened by erosion.

Transport for people and animals to safe shelter areas is also a priority need. During the monsoon season and in severe floods transport by engine boat, if it is available at all, becomes so expensive that many can barely afford it.

Water purification that is effective and acceptable is of the utmost importance during inundation and floods, when large percentages of char people in all char types drink polluted river water because hand tubewells are submerged. Fuels tend to be in short enough supply during the monsoon season to make boiling impracticable for many households.

Resettlement services for people displaced by erosion would under some circumstances provide them with *khas* land, and in other cases would require helping them secure jobs in urban or semi-urban areas. Policies are also required to help people get back to their original locations in chars if and when they re-emerge and become habitable.

9.5.3 Provision of Basic Services

Extension services: Char people would benefit from extension services on crop-diversification, seed storage, and irrigation. Extension services in livestock-raising could include mobile veterinary services at times when diseases are most common.

Health and sanitation services, as in many other rural Bangladesh communities, are in short supply in the charlands. Additionally, the cost of care prevents many from seeking skilled medical assistance in any but the most dire emergencies. Providing health care to people in island chars is difficult year-round, but it is especially problematic during monsoon season, when a mobile health team would be the best approach. The study found that risks from disease are greater than risks from flood waters during normal inundation and floods.

Review of the information obtained by the RRA survey indicates that sanitary conditions are poor in the charlands. In the absence of sanitation facilities, diseases like diarrhoea and dysentery are very common year-round. Initially, it is important to raise awareness of the necessity of good sanitation (in the middle Jamuna, SCI was found to be conducting such a program). Training people in the building of low-cost latrines (including ring latrines), which are not left exposed for long periods of time would be useful. Locating these latrines on relatively high ground would enable them to be used even during monsoon season.

Local government institutions, as well as NGOs, can play important roles in popularizing such ideas.

Schools: While there are primary schools in many charland mauzas, coverage is less than the national average and is poor in some island char areas. Even where there are educational facilities, keeping children in school during the monsoon season or during erosion-related migration is virtually impossible in many char areas. Improving primary education in charlands requires new approaches:

- buildings that are community-owned and that can be moved when erosion occurs. This could be done by having local members take responsibility for safeguarding the school on behalf of the village.
- encouraging staff to live in charlands, preferably by hiring local people.
- adjusting the curriculum and school year to the seasons.
- subsidizing boat services, particularly to improve access to high schools.
- since parents are unwilling to send young children on hazardous boat journeys, a primary school should be present on each inhabited island char.

Institutional credit: Institutional credit for agricultural inputs would encourage the use of better inputs and improve crop yields in the charlands. Access to credit for livestock and fishing equipment would also benefit char people.

9.5.4 Economic Development to Build Self-Reliance

Char people were particularly unhappy about the law that made any accreted land government property, but this has recently been changed back to protect private ownership if the land reappears within 20 years.

Land laws: There is a great deal of confusion about the land laws pertaining to alluvion and diluvion, and the existing laws are subverted by a variety of means to the benefit of the local elite. Char people were particularly unhappy about the law that makes any accreted land government-owned.

Establishing administrative boundaries: Conflicts between chars can often be traced back to confusions over administrative boundaries. Such lack of administrative clarity also leaves many of chars without public services. The inventory reports highlight many of these problems. Accurate surveys would help efficient administration.

Strengthening local government, the union parishad: Local government agencies can play an important role in keeping updated inventories of charlands for their areas. Such a role also would be useful in making damage assessments following floods and erosion, as well as in developing rehabilitation and resettlement strategies.

Existing social groups (kin groups, neighborhoods, and societies) should form the core of program development to the extent possible, as these groups tend to be interdependent and/or remain together when moving. If leadership is not exploitative, local leaders with the respect of char residents can help to promote innovative ideas and analyze program plans.

Innovative approaches must be utilized in any charland programming, because most existing local development activities are designed for more stable environments. Infrastructure creation, such as road building, as currently done is inappropriate in most charland situations. Policies and procedures that assume a stable land mass and a non-mobile public also need to be modified to accommodate the typically changeable charland situations in most river reaches.

Participatory program development (planning done in close consultation with beneficiary groups) is likely to yield the best results in the chars, because it can minimize the chances of setting up unworkable charland programs. Alternative types of earthwork, such as raising flood shelter mounds for cattle and people, are needed in charlands and could be accommodated within existing programs.

9.5.5 Policy Changes for Effective Land Use

Major improvements are required in policies relating to land law and the utilization of land. The inventory and RRA surveys found that although vast amounts of charland are technically government-owned *khas* land, such land is mostly under the unauthorized control of locally influential people. In fact, in many chars, the question of land access more often involves "control of land" than "ownership of land".

If the existing *khas* law is to remain in place, it should be enforced properly. Enforcement requires that measures be taken to prevent locally influential people from keeping *khas* land under their control in defiance of government directives. Proper enforcement also requires accurate information about charlands. Updated information on erosion and accretion needs to be available to the relevant government authorities at the local level (there currently is very little manpower available to accomplish this effectively).

The current policy of leasing out the *khas* land to individuals for agricultural purposes also needs to be reviewed. First, much of the *khas* land is not properly identified, making illegal occupation of land relatively easy. Second, in leasing out such land the authorities have failed to give priority consideration to the land-poor households that the law was intended to help.

Finally, given the impermanent nature of the land in many of the chars, and the transience of its population, it may be advisable to formulate a policy establishing cooperatives to utilize land resources that are legally under the ownership of the government. In certain cases the *samaj* has taken the role of arbiter in deciding how newly emerging *khas* land is utilized by its members. While such decisions have on many occasions been biased in favor of the *samaj* leaders, the *samaj*, with greater participation from the general members, can be used as a social platform to activate cooperatives.

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APPENDICES

Table A.1 (i) Char Development in the Jamuna (years)

Physical Characteristic	Upper	Middle	Lower (North)	Lower (South)	Total
Interval between Formation & Natural Vegetation					
Mean	1.1	1.2	1.45	1.02	1.15
Median	1	1	1	1	1
Interval between Natural Vegetation & Cultivation (No Settlement)					
Mean	2.97	2.59	2.09	1.76	2.29
Median	2	3	2	1	2
Interval between Natural Vegetation & Settlement (No Cultivation)					
Mean	2.39	1.77	1.24	1.33	1.67
Median	1	1	1	1	1
Interval between Natural Vegetation & Settlement with Cultivation					
Mean	1.25	1.1	1.15	1.04	1.11
Median	1	1	1	1	1
Settlement without Cultivation					
No. of Mauzas	1 (of 275)	0 (of 377)	0 (of 173)	6 (of 611)	7 (of 1,436)
Simultaneous Settlement & Cultivation					
No. of Mauzas	59 (of 275)	59 (of 377)	41 (of 173)	127 (of 611)	286 (of 1,436)
Separate Settlement & Cultivation					
Interval between Cultivation & Settlement					
Mean	2.23	1.3	1.06	2	1.62
Median	1	1	1	1	1
Interval between Settlement & Cultivation					
Mean	2.86	1.64	1.33	8.33	2.79
Median	1	1	1	1	1

Source: Charland Inventory

Table A.1 (ii) Char Development in the Meghna (years)

Physical Characteristic	Upper	Confluence	Lower	Total
Interval between Formation & Natural Vegetation				
Mean	2.5	1.44	1.21	1.39
Median	2	1	1	1
Interval between Natural Vegetation & Cultivation (No Settlement)				
Mean	3.46	1.9	2.58	2.3
Median	2	1	2	2
Interval between Natural Vegetation & Settlement (No Cultivation)				
Mean	3.89	2.96	6	4.71
Median	4	2	6	4
Interval between Natural Vegetation & Settlement with Cultivation				
Mean	2	2.2	1	2.14
Median	2	1	1	1
Settlement without Cultivation				
No. of Mauzas	0 (of 227)	2 (of 155)	0 (of 129)	2 (of 511)
Simultaneous Settlement & Cultivation				
No. of Mauzas	1 (of 227)	20 (of 155)	1 (of 129)	22 (of 511)
Separate Settlement & Cultivation				
Interval between Cultivation & Settlement				
Mean	1.6	2.26	3.75	3.52
Median	2	2	4	2
Interval between Settlement & Cultivation				
Mean	2.5	2.88	6	3.09
Median	3	2	6	2

Source: Charland Inventory

Table A.1 (iii) Char Development in the Ganges (years)

Physical Characteristic	Upper	Middle	Lower	Total
Interval between Formation & Natural Vegetation				
Mean	3.48	1.27	1.53	1.89
Median	2	1	1	1
Interval between Natural Vegetation & Cultivation (No Settlement)				
Mean	2.3	1.6	1.63	1.78
Median	1.5	1	1	1
Interval between Natural Vegetation & Settlement (No Cultivation)				
Mean	3.93	1.86	3.48	3.02
Median	3.5	2	3	2
Interval between Natural Vegetation & Settlement-cum-Cultivation				
Mean	1	1	1	1
Median	1	1	1	1
Settlement without Cultivation				
No. of Mauzas	0 (of 145)	0 (of 71)	0 (of 206)	0 (of 422)
Simultaneous Settlement & Cultivation				
No. of Mauzas	6 (of 145)	1 (of 71)	5 (of 206)	12 (of 422)
Separate Settlement & Cultivation				
Interval between Cultivation & Settlement				
Mean	2.88	1.2	2.5	2.25
Median	2.5	1	1	1
Interval between Settlement & Cultivation				
Mean	9	1.35	11	2.6
Median	9	1	11	1

Source: Charland Inventory

Table A.1 (iv) Char Development in the Padma (years)

Physical Characteristic	Upper	Middle	Lower	Total
Interval between Formation & Natural Vegetation				
Mean	1.67	1.34	2.12	1.66
Median	1	1	1	1
Interval between Natural Vegetation & Cultivation (No Settlement)				
Mean	2.1	1.43	2.45	1.95
Median	1	1	2	1
Interval between Natural Vegetation & Settlement (No Cultivation)				
Mean	3.93	2.59	2.81	3.22
Median	2	2	3	2
Interval between Natural Vegetation & Settlement with Cultivation				
Mean	1.63	1.08	1.2	1.33
Median	1	1	1	1
Settlement without Cultivation				
No. of Mauzas	0 (of 86)	0 (of 137)	0 (of 89)	0 (of 312)
Simultaneous Settlement & Cultivation				
No. of Mauzas	17 (of 86)	13 (of 137)	10 (of 89)	40 (of 312)
Separate Settlement & Cultivation				
Interval between Cultivation & Settlement				
Mean	3.49	1.65	1.87	2.52
Median	2	1.5	1	2
Interval between Settlement & Cultivation				
Mean	0	2	11.67	9.25
Median	0	2	1	1.5

Source: Charland Inventory

Table A.2 Percentage of Inhabited and Uninhabited Mauzas

	Inhabited			Uninhabited			
River	Cultivated	Noncultivated	Submerged	Accreted (non-vegetated)	Vegetated (non-cultivated)	Cultivated	No Information
Jamuna	87	13	5	43	11	29	12
Meghna	99	1	50	3	7	17	22
Ganges	99	1	7	17	17	40	19
Padma	99	1	40	14	17	27	2
Total	384	16	102	77	52	113	55

Source: Charland Inventory

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Table A.3 Land Use Sequence

River Reach	No. of Mauzas	Settlement with Cultivation	Settlement before Cultivation	Cultivation before Settlement
		JAMUNA		
Upper	109	54	6	39
Middle	147	40	7	52
Lower (North)	76	53	4	43
Lower (South)	173	73	2	25
Total	505	56	5	39
		MEGHNA		
Upper	9	11	22	66
Confluence	102	20	8	73
Lower	81	1	1	98
Total	192	11	6	83
		GANGES		
Upper	32	19	6	75
Middle	43	2	40	58
Lower	50	10	2	88
Total	125	10	16	74
		PADMA		
Upper	56	30	0	70
Middle	40	33	3	65
Lower	36	28	8	64
Total	132	30	3	67

Source: Charland Inventory