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Rivers, *chars* and *char* dwellers of Bangladesh

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ABSTRACT

Bangladesh consists mainly of riverine and deltaic deposits of three large and extremely dynamic rivers entering the country: the Brahmaputra, Ganges and Meghna rivers. The average flood discharges of these rivers (individually) are within the range of 14,000 to 100,000 m^3/s. Islands and bars are very common features among them all. In Bangladesh, both islands and bars are known as chars, but in this article only the vegetated islands within the riverbanks are referred to as chars. They are difficult to access and form an extremely dynamic environment for around 600,000 people that try to make a living under extreme and hazardous conditions of frequent and intensive flooding and erosion. People displaced by char erosion have no other alternative than to settle on accreting char land elsewhere, creating a typical social and economic char environment. The economics of the char lands are largely based on agriculture, fishing and livestock-rearing. Education, health and extension services and support to cope with the calamities of flood and erosion are minimal. This not only results in individual misery, but also in unrealized potential of resources on the chars.

Satellite imagery, available from the '70s onward, have facilitated several comprehensive studies of the dynamics of the rivers and chars. They have, in combination with social surveys, provided a good understanding of the interaction between the physical environment and the livelihoods of the char dwellers. They have also enabled predictions, e.g. on the total area and mobility of chars in the next decade. This has improved understanding and predictive capability that could lead to a better utilization of the potential resources of the chars to improve the livelihoods of char dwellers.

Keywords: Alluvial rivers; morphology; char dwellers; erosion; livelihood.

1 Introduction

In Bangladesh about 600,000 people live on riverine islands and bars, locally known as chars. This article attempts to link the dynamics of the lifestyle of these char dwellers to the dynamics of the physical settings of the chars of the major rivers of Bangladesh. It is intended to help identifying the constraints and to assist in suggesting suitable interventions in order to improve the livelihood of the char dwellers and thus achieve an optimum utilization of the potential resources in the chars.

This section presents the background, the area concerned and the sources of information used. The following sections present a description of the characteristics and dynamics of the rivers and chars, natural resources, demography, process of settlements, natural hazards and aspects of livelihood. Finally a section is depicted to consideration on management and future developments.

Background

In the processes of erosion and accretion of rivers, bars are created. Medial bars emerge in braided rivers, like the Jamuna, as islands within the river channel. Point bars emerge as land attached to the riverbanks in both braided and meandering rivers. These emerging lands are generally known as 'chars' in Bangladesh; they create opportunities for establishing human settlement and for pursuing agricultural activities. In this article, only the vegetated land is referred to as *char*.

Although the riverine chars in Bangladesh offer, on a continuous basis, significant areas of new land for settlement and cultivation, living and working conditions on these newly emerging lands are harsh. The chars are poorly connected to the mainland and are prone to acute erosion and flooding which make the inhabitants feel vulnerable. In spite of these physical problems, a significant number of people live there, enduring the difficult and uncertain conditions. It is to be noted, however, that the population density on chars is less than half the national average in Bangladesh. One can therefore surmise that the high demographic pressure in the country forces people to establish their settlements on chars, although the harsh livelihood conditions therein makes them less attractive for living than the mainland. The typical patterns of physical development and human use of land and other resources in the chars differ among the different river systems in Bangladesh and also among the different reaches of the same river.

This article mainly reports on the findings of a study by the Environment and GIS Support Project (EGIS, 2000). The EGIS study updates a former study by the Irrigation Support Project

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for Asia and the Near East (ISPAN, 1995) with new information on river dynamics, and better explains the link between the physical environment and livelihoods. The article also uses other more recent literatures (Schmuk, 1996; Haque, 1997; and Sarker and Thorne, 2003) and analyses to obtain more insight into the physical and social processes.

Study area

The ISPAN study, which forms the basis of this article, is primarily concerned with riverine chars in Bangladesh. It looks into two different kinds of chars: island chars and attached chars. Island chars are defined by the study as land that, even in the dry season, can be reached from the mainland only by crossing a main channel. Attached chars are 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).

The ISPAN study area (hereinafter referred to as the study area) extends from the border with India along the Ganges and the Jamuna through the Padma and the Lower Meghna as far as the northern edge of Bhola (Figure 1). Beyond the southern boundary of the study area, the Lower Meghna becomes increasingly estuarine in nature.

The study area is divided into five sub-areas: the Jamuna, the Ganges, the Padma, the Upper Meghna and the Lower Meghna rivers. Confluences mark the divisions between the different

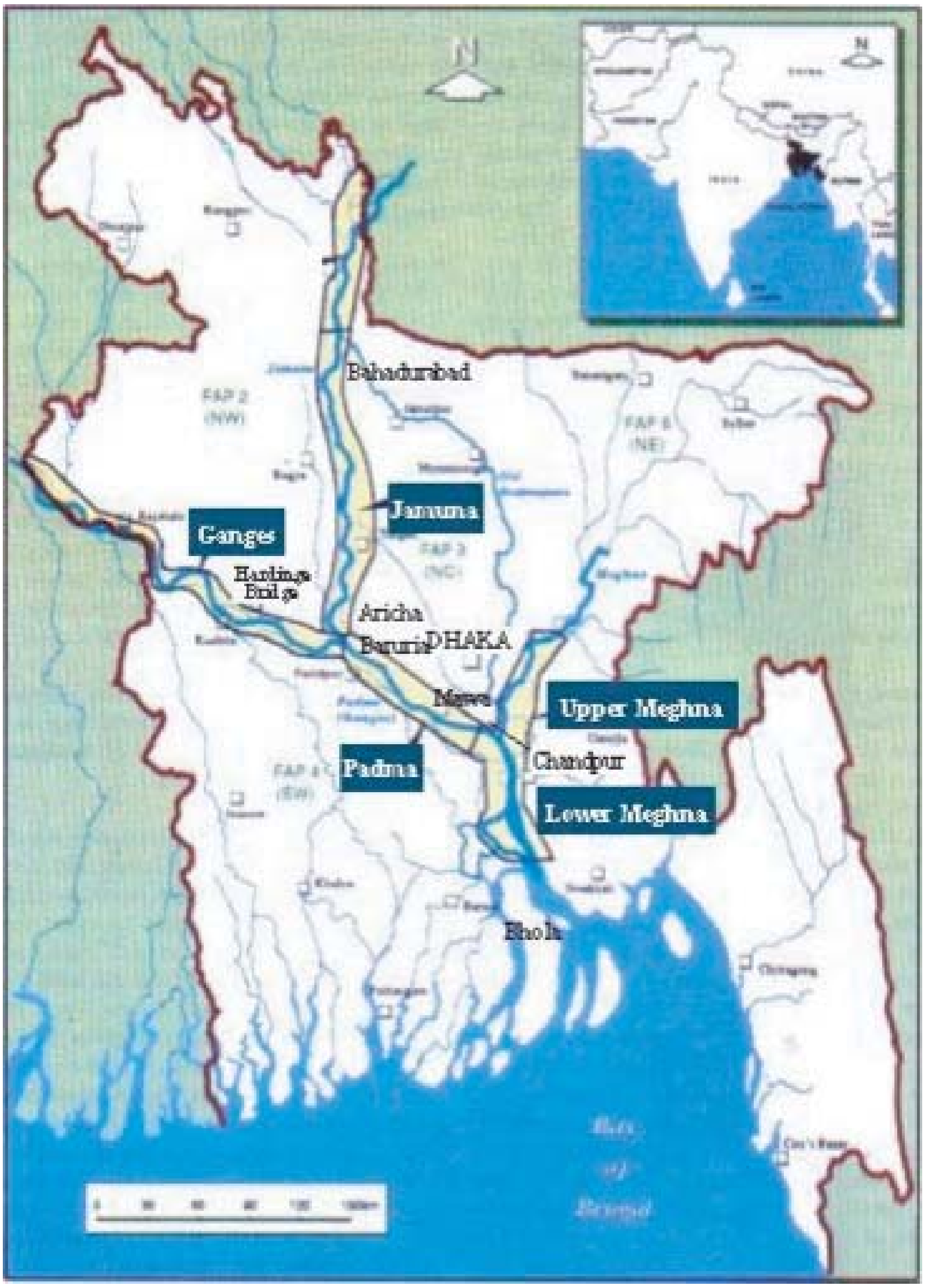

Figure 1 Study area.

rivers. The only exception is the Padma–Meghna confluence, where the flow of the Padma turns ninety degrees and where a complex and dynamic system of chars exists, which is included in the Lower Meghna study area. In fact, the Lower Meghna River is more of an extension of the Padma River than of the Upper Meghna River (see Haskoning *et al.,* 1992). The study area in the Upper Meghna extends up to the junction with the Old Brahmaputra River, downstream of which one can find typical island chars. There are other areas of riverine chars in Bangladesh, along the Teesta and the Old Brahmaputra rivers, for example. But compared to the chars in the major rivers, these constitute much less land area and are not included in the ISPAN study.

Sources of information

Two types of information were generated by ISPAN (1995). One was a set of inventories of the physical and demographic features of the chars for each of the five sub-areas. The second sought to understand the socio-economic aspects of life on the chars. To accomplish this second task, Rapid Rural Appraisals (RRA) were conducted in six different locations covering the major river systems of Bangladesh. During the compilation of the Charland Studies of ISPAN, the EGIS project updated the information on the physical aspects of the Jamuna River. Brief descriptions of the information sources are given below.

Inventory

The inventory part of the ISPAN study, relied heavily on satellite images. For the Jamuna, Ganges, Padma, and Meghna rivers, Landsat (TM and MSS) image analysis on char physiography was carried out by superimposing a dry season image of 1984 on a dry season image 1992 of 1993. Digital image processing and GIS analysis helped in identifying the land cover in chars and the patterns of erosion and accretion of land, as well as mapping and quantification of char age and char persistence. Similar to the earlier study by Klaassen and Masselink (1992) of the Jamuna area, four broad land cover classes were assigned in analysing each of the satellite images in the time series: water, sand, cultivated and vegetated land. Field-level checking was carried out before finalizing the classification of the images. Detailed reconnaissance information was gathered from the field on age of chars in the Ganges, Padma and Meghna rivers. This was done at the mouza level (the mouza is the smallest unit related to land administration). The mouza-level reconnaissance also gathered information on char type, soil characteristics, population, human migration, infrastructure, cropping pattern, livestock and flooding. The mouza-level field information and other secondary information were used for developing GIS data layers. GIS analysis of the different data layers helped to produce the maps and tabular outputs.

Rapid rural appraisal (RRA)

Rapid Rural Appraisals (RRA's) were conducted by the ISPAN study in six different locations of the river systems of the country (Upper Jamuna, Middle Jamuna, Ganges, Padma, Upper Meghna and Meghna Confluence) to generate relevant socio-economic information as well as information on the flood extent and duration of different floods over 1987 to 1991. The primary sources of information were key informants; for example, knowledgeable farmers, other occupational groups, members and ex-members of Union Parishads (the lowest administrative unit in Bangladesh), schoolteachers, fishermen, traders, landless people and women living in villages within the study area.

Flood proofing study

The flood proofing study (ISPAN, 1995) aimed at assessing household-level flood losses and developing flood proofing measures for char people. This study was based on a sample survey of households conducted in the upper (150 households) and lower (150 households) reaches of the Jamuna River.

Additional information and analysis

An effort was made to review relevant literature to obtain a better understanding of the historical process of evolution of the major rivers of the country (Goodbred, 1999; Goodbred and Kuehl, 1999; Khandoker, 1987; Morgan and McItire, 1959). In studying the river systems of the country and the process of char formation, a number of hydro-morphological characteristics were investigated at some length. This involved the analysis of such data as water level, water discharge and sediment transportation, measured by the Bangladesh Water Development Board (BWDB). Moreover, findings of the recent research of Sarker and Thorne (2003) were used to explain the behaviour of the rivers on a decade scale.

In analyzing river and char dynamics for the Jamuna River in terms of flooding, erosion, accretion, widening of channel, char persistence and char age, a larger number of Landsat (TM and MSS) images were used by the EGIS study covering a 27-year period (from 1973 to 2000). The additional analysis and new explanations of the river behaviour helped to introduce new perspectives on river and char dynamics.

2 Characteristics of the main rivers

Historical evolution

The Bengal basin is floored by Late Quaternary sediments deposited by the Jamuna, Ganges and Meghna rivers and their several tributaries and distributaries. This basin is tectonically active. Uplifting and subsidence are the predominant processes of the Quaternary period. The Madhupur and Barind tracts are Pleistocene uplifted alluvial deposits (Morgan and McIntire, 1959). The Sylhet Basin is subsiding at a rate of 1–3 mm/y (Goodbred, 1999). In most of the Bengal basin, including the coastal zone and offshore areas, compaction and/or isostatically induced subsidence occurs (Goodbred and Kuehl, 1999).

In addition to the tectonic activities, the formation of the Bengal Basin is strongly influenced by the huge input of sediment (10^9 ton/y) from the catchments of the main rivers. The main source of the sediment is the Himalayas, which are geologically young and active. Part of the sediment serves to fill up the subsidence (mainly in the Sylhet Basin) and compaction areas, like the southwest delta plain.

In Bangladesh, a major avulsion took place in historical times. Around 1770, the Brahmaputra flowed through the present course of the Old Brahmaputra River. At the beginning of the 19th century a new channel (called the Jamuna River) had evolved, carrying the major part of the discharge of the Brahmaputra River. The Jamuna River met with the Ganges River almost at their present confluence at Aricha. In the middle of the 19th century their joint flow (called the Padma River) cut through relatively cohesive sediment dividing the Padma River from the Upper Meghna River and met with the Meghna River at the present location of their confluence. The combined flow then formed one of the world's largest rivers known as the Lower Meghna River.

At the beginning of the 19th century, the planform of the Jamuna River was essentially that of a meandering river, which gradually transformed into a braiding planform. The old maps and the recently available satellite images suggest that the planform of the main rivers had changed from meandering to braiding and vice versa over the last two decades. Moreover, the braiding index of the river is changing over time (Klaassen and Vermeer, 1987). Changes in the hydraulic or sediment regimes on the decade scale are probably responsible for these changes in planform.

Hydro-morphological characteristics

The catchments of the three main rivers flowing through Bangladesh lie in China, Nepal, Bhutan, India and Bangladesh (Figure 2). The total catchment area is about 1,650,000 km^2, which is more than eleven times the total area of Bangladesh. Precipitation patterns and geological characteristics in the catchments vary widely. The key hydro-morphological characteristics of the rivers are presented in Table 1.

Table 1 shows that among the three main rivers, the catchment of the Ganges is the largest but the average annual rainfall is the lowest. On the other hand, the catchment of the Upper Meghna River is the smallest but the rainfall is the highest. However, the annual average run-off produced by the catchment of the Jamuna is the highest, nearly double that of the Ganges River and 5 times that of the Upper Meghna River.

The Jamuna River drains the rainfall and snowmelt from China, Bhutan, India and Bangladesh. The length of the Jamuna River in Bangladesh is about 240 km measured from its international border to the confluence with the Ganges at Aricha. The river starts rising in March/April due to snowmelt in the Himalayas and attains its peak between mid July and end of August. The maximum discharge at Bahadurabad, the only discharge gauging station at the Jamuna River, is estimated at 100,000 m^3/s (1998). The minimum flow occurs at the end of February or the beginning of March. The difference in water levels between flood and dry season is about 6.5 m at Bahadurabad, which gradually reduces in the downstream direction. The surface water slope of the Jamuna River reduces from 8.5 cm/km upstream to 6.5 cm/km downstream. The bed material size also reduces in the downstream direction. The average annual sediment transport through the river is nearly 600 M ton/y among which two thirds is wash load i.e. silt and clay. The Jamuna River is braided in planform, the braiding intensity (ratio of the total length of the channels in a reach and the corresponding valley length) of which is about 4 to 5. Braiding intensity varies over time and reduces downstream.

The Ganges drains the southern slope of the Himalayas. After entering Bangladesh, the river flows about 100 km along the international border of Bangladesh and India. Before meeting with the Jamuna River it travels about 130 km within Bangladesh. The river starts rising at the end of June or the beginning of July and attains its peak levels from mid August to mid September. The recorded maximum flow in the Ganges at Hardinge Bridge was 78,000 m^3/s (1988). The minimum flow occurs in March or April, the present range of which is a few hundred m^3/s. After the Farakka Barrage in India became operational in the mid 70s, the minimum flow is mainly determined by the amount of water

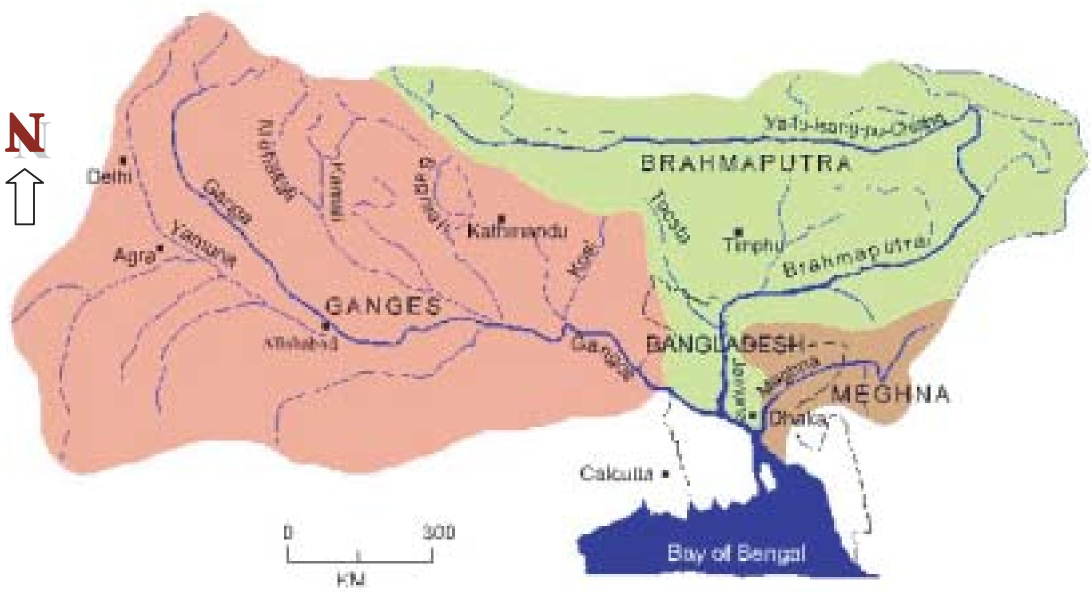

Figure 2 Catchment of the Ganges, Jamuna and Meghna rivers.

Table 1 Key hydrological characteristics of the different rivers.

Parameters		Jamuna (Bahadu-rabad)	Ganges (Hardinge Bridge)	Padma	Upper Meghna (Bhairab Bazar)	Lower Meghna (Chandpur)
Catchment area (10^3 km^2)		573	1,000	—	77	—
Average annual rainfall within the catchments (mm)		1,900	1,200	—	4,900	—
Average annual discharge (m^3/s)		20,200	11,300	30,000	4,600	—
Discharge(m^3/s)	Average flood	70,000	52,000	95,000	13.700	
	Average low flow	4,250	600	4,800	—	
Water(m + PWD)	Average maximum	19.1	13.7	5.5	6.0	4.0
	Average minimum	13.6	5.4	1.5	1.5	1.0
Slope (cm/km)		7.5	5	5	2	5
Total sediment transport (M tons/y)		590	550	900	13	—
Bed material transport (M tons/y)		200	195	370	—	—
Bed material size (D_{50}) (mm)		0.20	0.15	0.12	0.14	0.09
Planform		Braiding	Wandering	Wandering	Anastomosing	Wandering

remaining in the Ganges after diversion of water towards the Hoogly River in India.

Compared to the other rivers, sediment concentration is highest in the Ganges River. Two thirds of the transported sediment consists of silt and clay and the rest is bed material. The Ganges River has a predominantly meandering planform, although some reaches of the river show a braiding pattern. This braiding varies spatially and temporally.

The Padma River carries the combined flows of the Jamuna and Ganges rivers. At Mawa, the tidal influence can be felt during low flow conditions with a tidal range of about 0.5 m in February and March. The bed material of the Padma River is finer than that of the Ganges and the Jamuna rivers. About 60% of the transported sediment consists of silt and clay and the rest is bed material. The planform of the river varies spatially and temporally from straight to braiding.

The Upper Meghna River drains the Manipur Hills and the Meghalaya Hills in India, where the average annual rainfall is very high (12,000 mm). This is a rain-fed river, which attains its peak in August. The average flood discharge is 13,700 m^3/s (Kruger Consult, 1992). The study area encompasses the downstream part of the Upper Meghna River, where chars are present. It should be mentioned here that this reach is the former bed of the combined flow of the Brahmaputra and Upper Meghna rivers and the channel is still adjusting its dimension to its present flow (and sediment) regime (Haskoning *et al.*, 1992). The river is anastomosed in planform, which is characterised by multi-threaded channels around high and vegetated permanent chars, and a very gentle slope, even less than observed in many meandering rivers (Thorne, 1997). This is explained by its history and the slow filling-in of the channels (Haskoning *et al.*, 1992).

The Lower Meghna River is mainly the combined flow of the Padma and Upper Meghna rivers. The river is fully under tidal influence during the dry season; the average range of spring tide is 1.5 m. The planform of the river varies from straight to braided.

3 Rivers and chars

River dynamics

Along alluvial rivers, bank erosion is a common phenomenon. However, the intensity of bank erosion varies widely from river to river as it depends on such characteristics as bank material, water level variations, near bank flow velocities, planform of the river and the supply of water and sediment into the river. Bank erosion processes in meandering and braided rivers are different. In a meandering river, bank erosion occurs along the outer bends, while accretion occurs at inner bends. In a braided river, bank erosion may not be always associated with accretion, and erosion and accretion might occur simultaneously at both its banks.

Length-averaged bank erosion rates during the period 1984–1993 are found to be much higher along the Jamuna, Padma and Lower Meghna rivers than along the Ganges and Upper Meghna rivers. This rate is an indicator of the characteristics of bank materials and river flow. For example, the floodplains along the right bank of the Jamuna River are older than those along the left bank. Though a long-term westward migration trend is present, the bank erosion was higher along the left (east) bank during the widening phase of the rivers. Similarly, the floodplains along the left bank of the Padma and Lower Meghna rivers are older than those along the right bank, and the length-averaged bank erosion rate was found to be much higher along the left bank (Table 2).

Existence of cohesive bank materials along the boundary of the active corridor limits the length-averaged bank erosion rate. These cohesive bank materials are likely to be continuous along the left side of the corridor of the Ganges and Padma rivers and discontinuous along the right side. Maximum bank erosion along the Ganges is expected to occur along its right bank. On the other hand, floodplains along the Upper Meghna River consist of recently deposited material, although the bank erosion rate is found to be very low. This can be explained by its low energy nature attributed to the very flat slope of the river during floods,

Table 2 Bank erosion/accretion and changes in width of the different rivers in Bangladesh over the period 1984–93.

Item		Jamuna	Ganges	Padma	Upper Meghna	Lower Meghna
Length-averaged bank erosion rate (m/y)	Left bank	100[a]	−20	38	7	65
	Right bank	84[a]	56	120	−9	180
Maximum bank erosion rate (m/y)		780[a]	665	620	NA	825
Bank erosion (ha/y)		5,020[a]	2,240	1,800	50	1,170
Bank accretion (ha/y)		890[a]	1,010	230	50	400
Average width (m)	1984	9,720	4,367	5,690	3,400	6,660
	1993	11,220	4,693	7,120	3,400	8,900
Rate of change of width (m/y)		184	36	159	—	249

Notes: [a] rates derived for the period 1984–92, width in 1992.
Source: ISPAN, 1995.

the Upper Meghna River being the remnant of the Brahmaputra River flowing through its now Upper Meghna course until about two centuries ago (Morgan and McIntire, 1959; Haskoning *et al.*, 1992).

The very high length-averaged erosion rates along the Jamuna, Padma and Lower Meghna rivers (Table 2) indicate that these rivers were widening at a very high rate during the study period. Analyses of the bank lines of the Jamuna River derived from time-series satellite images show that this river has been widening since the early '70s (Figure 3), but the yearly rate seems to have reduced significantly since the late '90s. The widening of the river in a 28-year period resulted in a net loss of floodplain area of 70,000 ha (2,600 ha/y) over the total length of 220 km of the river in Bangladesh. Within the 1984–1992 period, the river has eroded 40,000 ha of floodplain and accreted 9,140 ha of land, corresponding to an erosion rate of about 5,000 ha/y and an accretion rate of about 1,400 ha/y (Table 3 and Figure 4).

Like the Jamuna River, downstream rivers such as the Padma and Lower Meghna were widening at a very high rate during the study period. A recent research carried out by Sarker and Thorne (2003) showed that these widening processes were related to the traveling of the coarse sediment (fine sand) generated during the great 1950 Assam Earthquake through the system. They developed a process-response conceptual model based on the observations of the morphological changes during the last few decades. According to the model, the widening of the braided rivers started when the sediment input started to decline from its peak during the early '70s and a further decrease in the sediment input increased braiding intensity, bank erosion and widening. In the '70s and '80s the river became "wild". Analyses of bank erosion rates using satellite imagery indicate that very high rates of bank erosion were apparent during the '80s and early '90s. During interviews, char dwellers expressed that in the '70s the Jamuna River had started to behave like a "crazy river" (Schmuck, 1996).

Data presented by Sarker and Thorne (2003) also indicated that the width of the upstream reaches of the Jamuna River has started to decrease in recent years. According to them, the apparent widening of the Padma and Lower Meghna rivers as observed in 1984–93 will continue for a few more years and may stop at the mid or end of the first decade of this century.

The apparent widening of the Ganges River is mainly due to the enlargement of the meandering loops from the upstream boundary of the study area to the Hardinge Bridge (Figure 5). Recent analyses of the time series satellite images by the Center for Environmental and Geographic Information Services (CEGIS) found that from 1973 to 1999 the sinuosity of a 137 km long stretch of the Ganges River from the Farakka Barrage in India to the Hardinge Bridge increased by 20% and that the corresponding increase of the length of the river was 27 km. This increase in sinuosity is possibly attributable to the temporary blocking of sediment by the Farakka Barrage.

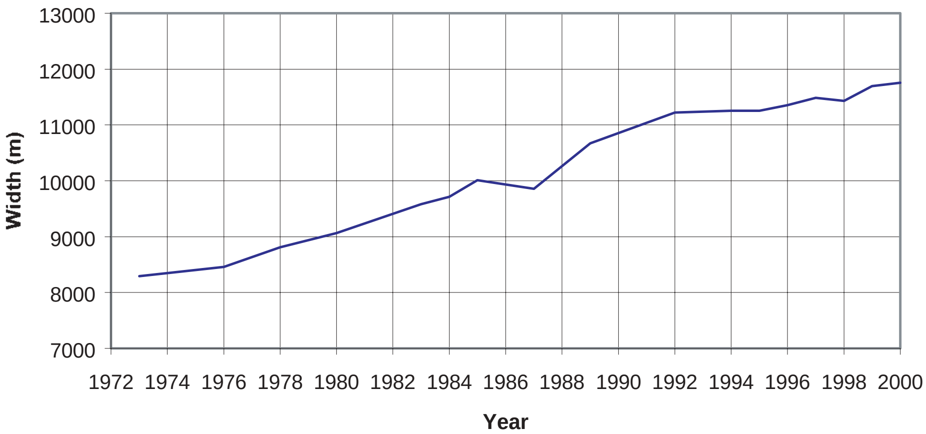

Figure 3 Recent trend of widening of the Jamuna River (1973–2000).

Table 3 Areas of water, sand and chars (derived from classification of satellite images) and extent of flooding within the riverbanks.

Item		Jamuna	Ganges	Padma	Upper Meghna	Lower Meghna
Total water area (ha)	1984	55,740	28,620	43,400[c]	7,950[c]	45,610[c]
	1993	61,240[a]	28,980	57,720[c]	8,440[c]	57,680[c]
Total sand area (ha)	1984	54,010	36,230	—	—	—
	1993	70,240[a]	35,660	—	—	—
Total vegetated land: chars (ha)	1984	89,580	24,350	6,250	5,050	11,070
	1993	98,760[a]	35,560	15,270	4,630	18,070
Total area within the banks	1984	199,330	89,200	49,650	13,000	56,680
	1993	230,240	100,200	72,990	13,070	75,750
Ratio of attached char area and island char area	1993	1.00	1.56	1.22	All chars are island char	
Average flooded area in 1989–1992 (%)	Attached	50[b]	65	47	—	—
	Island	50[b]	83	72	68	49

Notes: [a] 1992 data, [b] flood extent in 1991, [c] area of water and sand.
Source: ISPAN, 1995.

Char formation

A distinction should be made between island chars, which are surrounded year round by water, and attached chars, which are connected to the mainland under normal flow conditions. The formation process and characteristics of these chars are different in braided and meandering rivers, while within a river the char characteristics may vary in the longitudinal direction. Generally, chars upstream consist of coarser materials compared to those downstream. The height of the chars above low or average water levels would depend on the annual water level variations.

In a braided river, the formation of an island char would deflect the river flow to both sides, tending to widen the river through bank erosion. This process of widening of the river and sediment becoming available from the eroding banks would enhance the process of continued bar building. Clusters of bars could be formed that eventually merge to form larger and more permanent island chars. The development and abandonment of channels are very common phenomena in a braided river like the Jamuna (Klaassen and Masselink, 1992). Abandonment of any outflanking channel can convert an island char into an attached char.

In a meandering river, two types of reaches exist: bends and crossings. Meandering bends are always associated with point bars. Point bars are believed to be formed through secondary currents, which erode the outer bank of a meandering bend and deposit sediment in the inner bend. The topography of this type of chars has a typical pattern; it is elevated at the upstream part of the inner bend and gradually slopes down in the downstream and from the bank towards the river. Point bars i.e. attached bars in a meandering river are different from attached bars in a braided river. Attached bars in a braided river have the same characteristics as a medial bar in the sense that these will be elevated at the tip of the bar, with the slope gradually declining in the downstream and toward each of the flanks.

In a wandering river where the planform is between meandering and braiding, medial and attached char formation processes are different from those in the braided rivers. In these rivers, large sweeping meandering bends produce point bars. In locations where chute channels remain active in both dry and wet seasons, island chars are also created. After the disappearance of the chute channels, such island chars become attached chars. In a braided reach of the wandering river, medial bars first emerge as island chars, which may become attached chars if the channel reaches become meandering or the anabranch near the floodplain is abandoned. Given this order of development, it is likely that in the wandering rivers the attached chars are older than the island chars. This is confirmed by the fact that in wandering rivers, the area flooded is lower in the attached chars compared to the island chars.

When a char emerges, it consists of sand of approximately the same coarseness as the bed material of the river reach. However, at the lee side of a medial or point bar, fine materials would deposit. When the bar elevation reaches close to average flood levels, a layer of silt and clay is deposited over the sand layer, facilitating the development of vegetated islands named as chars. As the chars grow older, their levels increase and attain the height of the adjacent floodplains. This process might be interrupted by subsequent lateral erosion of the chars.

Dynamics of chars

Char dynamics relates to the morphological behaviour of rivers and in particular to the bank erosion processes and the prevailing trends of widening and narrowing of rivers. Widening of rivers increase char areas. However, increase in char area is not necessarily the same as the loss of floodplain (Table 3) resulting from widening. The growth of vegetation on sand bars always takes time, which might be one of the reasons why the increase of char areas was found to be less than the increase of char areas within river banks. This is especially true for the rivers in which the rate of increase of the area within the river bank were high such as in the Jamuna, Padma and Lower Meghna rivers. For example, from 1984 to 1993, the area within the river banks along the Padma increased by 47% while the char areas increased by only 18%. The widening rate of the Ganges River was relatively small compared to the other rivers and the increase in the area within the

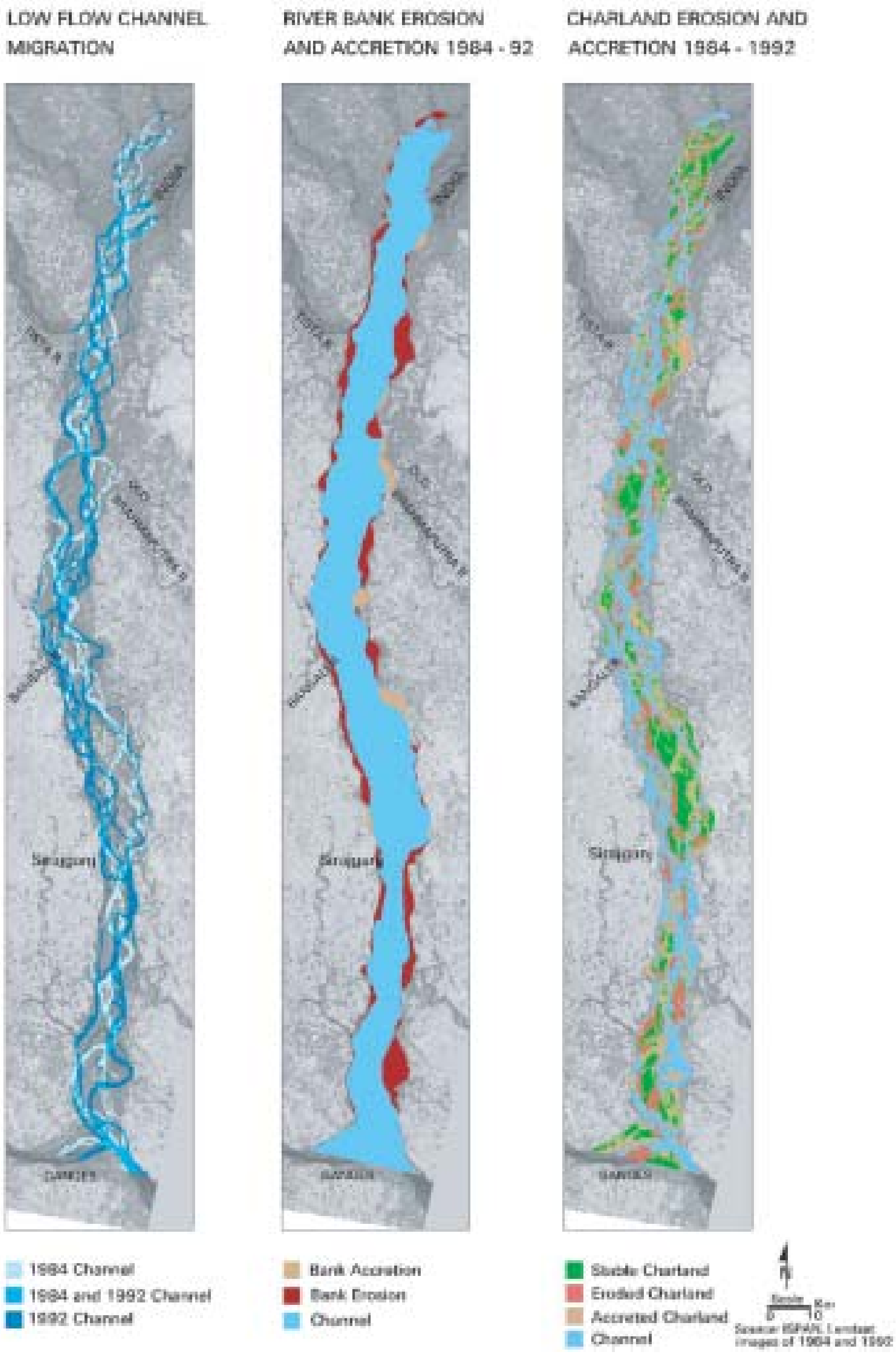

Figure 4 Low flow channel migration, erosion and accretion in the Jamuna River (1984–92).

banks was found to be fully compensated by the increase in the char areas (Table 3). In the most stable rivers such as the Upper Meghna River, changes in the char areas are negligible.

River and char dynamics can be assessed from the Figures 4, 5, 6 and 7 where the changes in the dry season channels, bank erosion/accretion and char erosion/accretion of the Jamuna, Ganges, Padma, Upper Meghna and Lower Meghna rivers are shown for the period 1984–1993. More detailed analyses were performed for the char dynamics of the Jamuna River. To assess the dynamics of the chars, char incidence, char age and char persistence maps were prepared using 17 classified images, spanning the period between 1973 and 2000 (Figure 8).

The char incidence map shows how many times chars appear at different locations of the Jamuna River. The char age map shows the age of the chars visible in the dry season images of 2000. Char persistence during a specific span of time is the number of years for which a given location shows continuous presence of chars. Since many within-bank locations that were water or sand in 2000 have previously been char land, the life cycle of these chars was taken into account in estimating char persistence. The result of the analysis for char age and char persistence is presented in Tables 4 and 5. In the Jamuna River, the chars are very young. Almost 68% of the chars are found to be less than 6 years old, whereas only 60% of the chars are found to persist for 1 to 6

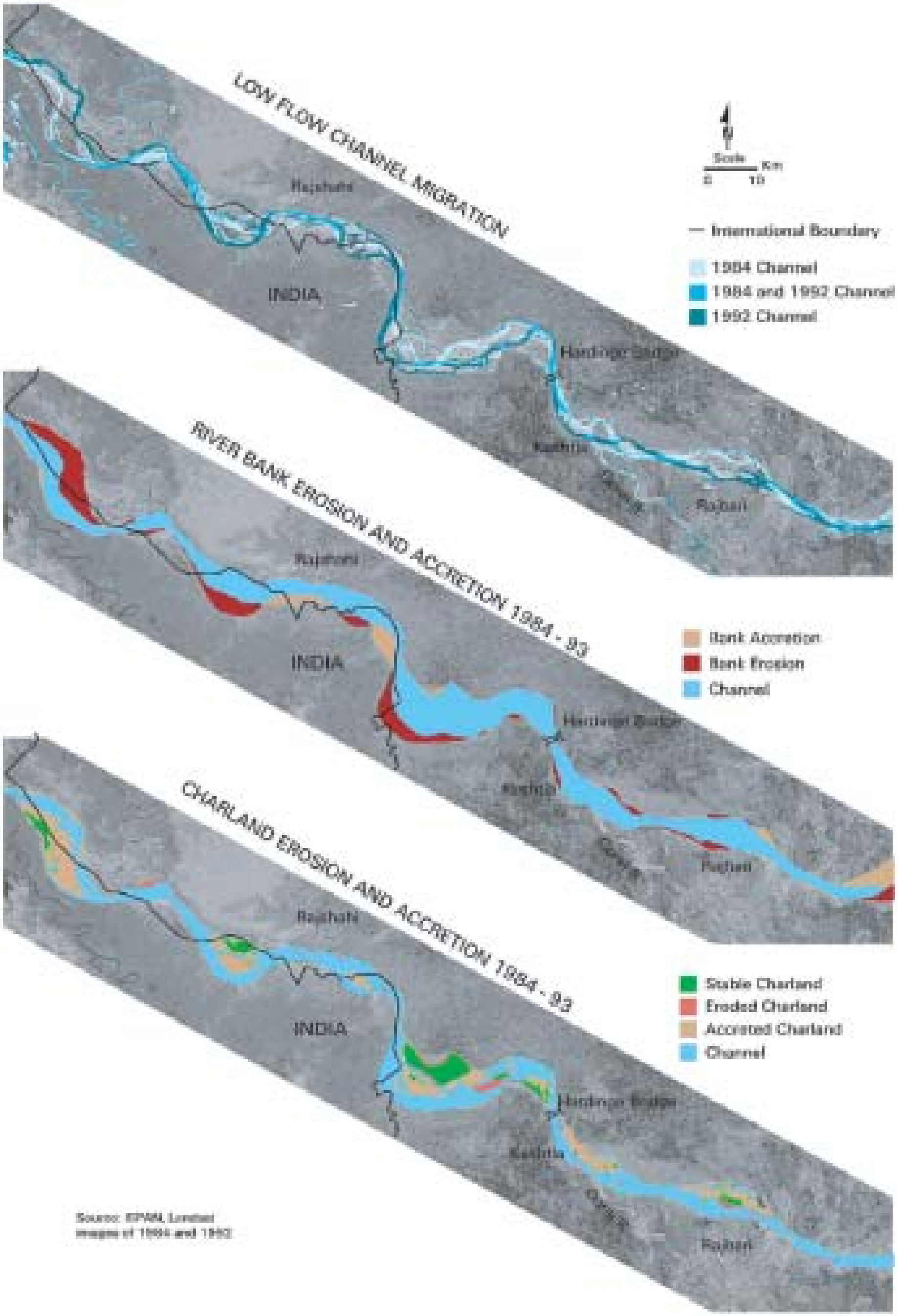

Figure 5 Low flow channel migration, erosion and accretion in the Ganges River (1984–93).

years. The char areas that are found to persist more than 27 years are only 2.2% of the total char areas within-banks in 2000.

The Ganges, Padma and Lower Meghna rivers are categorized as wandering rivers, showing a mixed pattern of meandering and braided stretches. The chars in these rivers seem to be more stable than in the Jamuna River. It is to be noted that the active corridor of the Ganges River is bound by erosion-resistant materials. This might have contributed to the stability of the chars in this river. Besides, the stability of chars in wandering rivers could be explained by the fact that in such rivers attached chars develop out of island chars, which results in a continuity in the process of char formation. This is absent in a braided river, where the attached and island chars are formed more randomly and independently. As a consequence, the persistence of chars in the Ganges, Padma and Lower Meghna rivers can be predicted better than the persistence of the chars in the Jamuna River. In an anastomosing river such as the Upper Meghna, the chars are likely to be much more stable than those in braided or wandering rivers.

4 Natural resources

Land

In general, the downstream parts of rivers experience deposits of finer sediment (silt), which make the lands in chars quite fertile. The fertility of land in many of the chars has historically attracted many to exploit their agricultural productivity. It is to be noted that sand itself can be an economic resource if it can be marketed

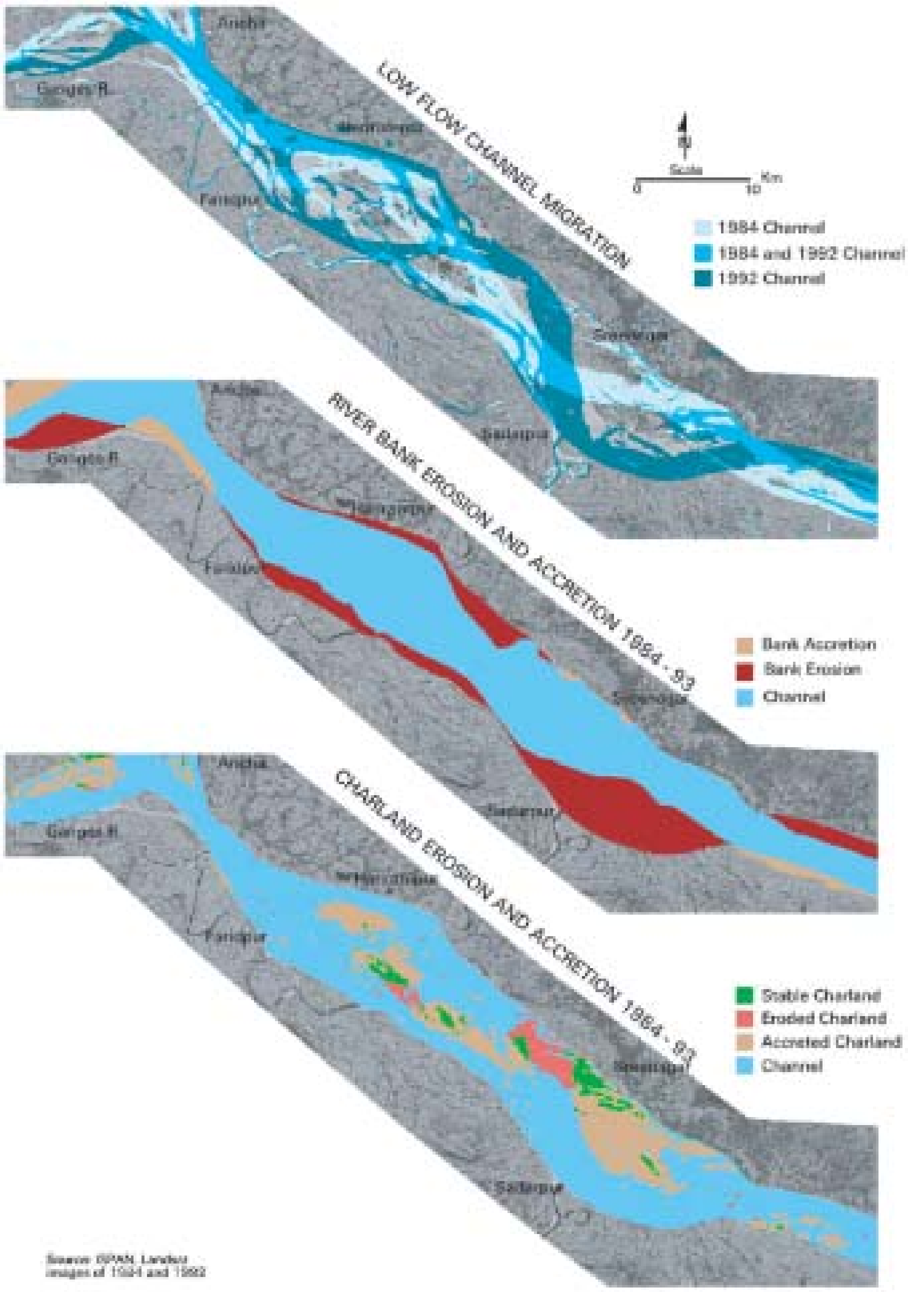

Figure 6 Low flow channel migration, erosion and accretion in the Padma River (1984–93).

commercially to urban centers where it is used for construction purposes. For this purpose, sand was collected from some chars at the Upper Meghna and Ganges RRA locations.

In taking stock of the char resources, it is useful to take separate looks at the categories of island and attached chars. The Upper and Lower Meghna reaches have no attached chars. In the Jamuna and Padma rivers, the distribution of land between attached and island chars did not show significant differences. In the Ganges, however, more than 60% of the char area is under attached chars. In all river reaches excepting the Upper Meghna, people consider the island chars to be relatively hazardous in terms of flood and erosion vulnerabilities. The island chars of the Upper Meghna are more stable and less prone to these vulnerabilities.

Wide expanses of grazing land constitute another economic resource in some chars, particularly in the chars of the Upper Jamuna. The availability of grazing land has encouraged cattle raising in many chars. This is more prominent in those chars that are less vulnerable to frequent flooding.

Vegetation

Newly accreted land, if it does not erode quickly, is initially colonized by grass, particularly catkin grass (Saccharum spontaneum, for example). Dense growth of catkin grass can accelerate silt deposition on chars. Decomposition of the grass also adds humus to the soil. Although this grass grows naturally on newly accreting chars, there are instances where inhabitants, or potential inhabitants have planted the grass on newly emerging land to hasten its conversion to agricultural land.

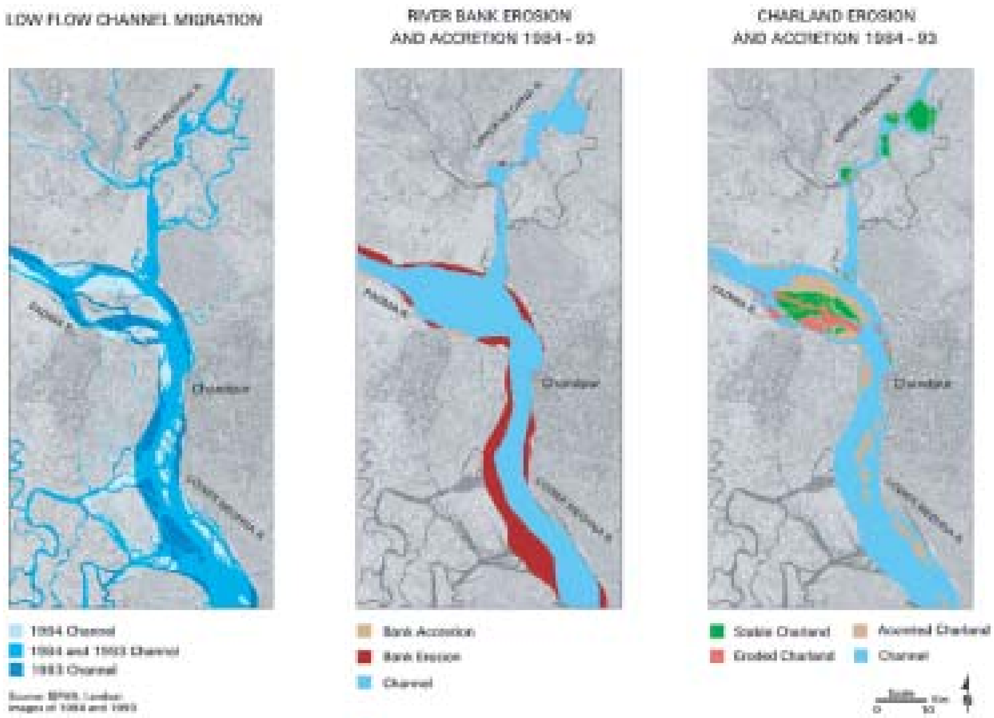

Figure 7 Low flow channel migration, erosion and accretion in the U. & L. Meghna rivers (1984–93).

Catkin grass is a multipurpose resource. It is extensively used by the people of chars as thatching material for their houses. It is also a source of cash for those who sell the grass in nearby mainland markets as thatching material. The stem of the plant is quite commonly used for making fences. In some char areas, traders buy large quantities of catkin grass to be sold to betel leaf gardeners who use it for covering the roofs of enclosures made for producing betel leaf. The other major use of catkin grass is as fuel. It is mainly due to the abundant supply of catkin grass in chars that people living there are relatively better stocked with fuel for the entire year. The grass is also used as fodder. When floods inundate homesteads, cattle owners often make mounds of catkin grass for their cattle to stand on, raising them above the floodwater. Catkin grass is also placed around the outer side of the earthen plinths of houses before monsoon to reduce the possibility of damage due to excessive rain, inundation, or waves.

Although the relatively new chars have very few trees, some older chars have a variety of fruit and timber trees, including mango, jackfruit, guava, bamboo, shimul, and jiga. Banana plants are very commonly found in and around the homesteads. They provide privacy for the homestead and act as protection against wind, which can be quite strong there at times. The banana fruit is an important source of food and cash, and the trunk is sometimes used for making rafts, particularly during floods. People do not invest in planting slow-growing and relatively permanent trees on those chars that they perceive to be erosion-prone in the short-run.

Open-water fish resources

Since chars are located within or by the side of rivers, the people living there enjoy an advantage of proximity to the fisheries resources therein. The nature of fishing in which char people are involved depends on whether the area is close to major fish habitats, spawning grounds or migration paths of fish. The Upper Meghna River, which is adjacent to an extensive floodplain, constitutes an important habitat for many different species of fish. Areas near the Meghna Confluence and the Padma River are important for the fishing of migratory hilsha. The Jamuna around the town of Bhuapur, and to a lesser extent the Padma near the town of Faridpur, are key areas for the catching of fish spawn and fry, particularly those of carp. The fishing activities of the char people are also influenced by the availability of fish and the ease of fish catch during different seasons of the year. Besides, in certain parts of the rivers, leasing arrangements play an important role in characterizing the nature and intensity of open water fishing.

5 Demography

The population density of the chars is nearly half of the population density of Bangladesh (763/km^2 according to the 1991 Census). Population density in the different types of chars in 1984 and 1993 within the different rivers is presented in Table 6. It is to be noted that the population densities of the Lower and Upper Jamuna are averaged to obtain one density figure for the whole of the Jamuna. As expected, the density of the attached chars is found to be greater than that of the island chars in all of the rivers where both types of chars exist. This pattern is more pronounced in the chars of the Ganges and the Padma rivers than in the Jamuna River, which is partially explained by the differences in flood proneness. The highest density is found in the Upper Meghna where the chars are relatively old and stable. Examining the inter-temporal changes in population density, increases

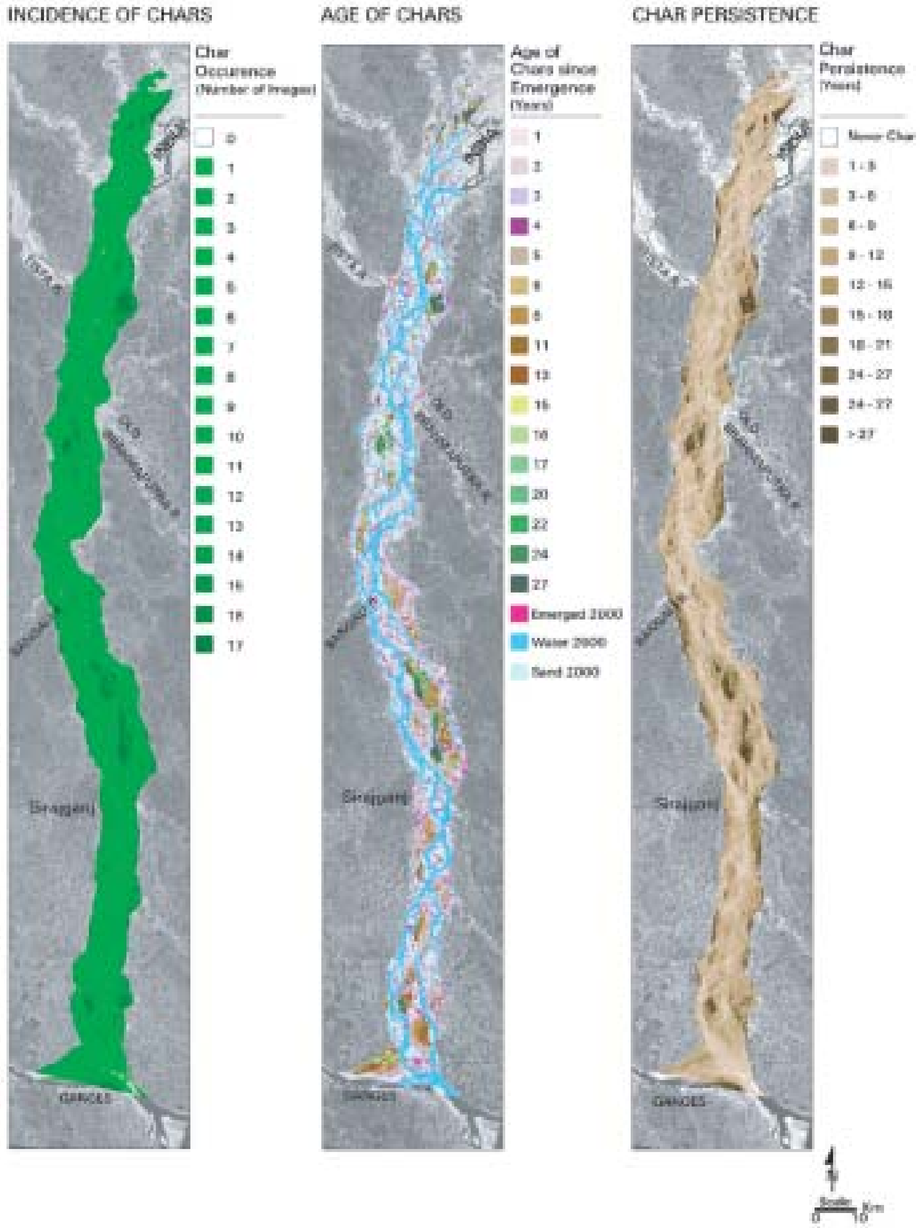

Figure 8 Char dynamics in the Jamuna River (1973–2000).

are found in the chars of the Jamuna, Upper Meghna and Lower Meghna rivers, whereas decline is recorded for the Ganges and the Padma rivers. It is to be noted that although from the physical point of view the Ganges chars are quite stable, both due to high flood vulnerability (Table 3) and relatively low fertility of land, the population density in these chars is rather low. In the Padma River, char areas increased more than 140% within 9 years (1984–1993), but the rate of increase in settlement is relatively lower and this is probably the reason for the decrease in the population density in the chars.

Using the figures on vegetated char area within bank lines (Table 3) and population density in Table 6, population figures are estimated for the chars of the different rivers, which are presented in Table 7. It is to be noted that the population estimates for 1984 are based on 1981 population densities.

As reported in Table 7, the total population in the chars in1993 works out to be around 630,000. The majority of these people, which is almost 65%, live on chars in the Jamuna River. The char population in 1993 represents a 47% increase over the population in 1984 (caused by increases in both char area and density of population in chars). The national population growth over the same period is estimated to be 26%. Thus, one can see the growing importance of chars in providing land for human habitation in Bangladesh. The increase in char population is accounted for more by the people inhabiting the island chars than the attached chars. Thus, while the population increase in the attached chars has been to the tune of 19%, the corresponding figure for the island chars has been as high as 88%. Studying the data for the rivers separately, one can see that there have been substantial increases in char population in all the rivers. The lowest percentage increase over the period is reported for the Upper Meghna (26%, which corresponds with the national figure). However, the increase has been most phenomenal on the island chars of the Lower Meghna (an increase of over two hundred percent).

Table 4 Char age in the Jamuna River.

Char age (years)	Percentage[1]
Char emerged in 2000	30
1–< 3	26
3–< 6	12
6–< 9	8
9–< 12	4
12–< 15	6
15–< 18	3
18–< 21	2
21–< 24	1
24–< 27	1
≤ 27	6

Note: [1] percent of char area in 2000 (90,000 ha).

Table 5 Char persistence in the Jamuna River.

Char persistence (year)	Percent[1]
Never char	0.4
1–< 3	25.1
3–< 6	34.3
6–< 9	16.7
9–< 12	9.1
12–< 15	3.9
15–< 18	1.4
18–< 21	2
21–< 24	2.4
24–< 27	2.6
≤ 27	2.2

Note: [1] Given as percentage of within banks area in 2000 (240,500 ha).

Considering the stability of the chars and natural resources availability, the chars in the Upper Meghna River is expected to be attractive for human settlements, and the data concurs with this premise. On the other hand, after its avulsion 200 years ago, the Jamuna River grasped nearly 260,000 ha of land and only in the last 28 years destroyed a net 70,000 ha of land. It implies that only in the last few decades, the river displaced hundred thousands of people. After its avulsion, this braided river has created the opportunity to live on chars and the people living along the river have a long experience in coping with the prevailing harsh environment there. This is probably why the density of population in the chars of the Jamuna River is higher than that of the Ganges River, although the stability of the chars is less than that of the latter river.

6 Settlement processes

Of all the rivers, the braided Jamuna River has by far the largest area of charland. In 1992, the total area of chars in this river was 100,000 ha, compared to 75,000 ha for all other rivers together. Also in terms of percentage of total within-bank area covered by chars, the Jamuna has a higher figure than the other rivers. Thus, while this figure works out be 45% for the Jamuna, the corresponding figures for the wandering rivers, the Ganges and the Padma, are 30% and 20%, respectively. The figure for the Lower Meghna River is 20% only, while that for the Upper Meghna (where very stable chars are found in an anastomosing river) is 40%.

Once the chars are formed, different kinds of progression are observed in terms of human population making use of the land therein. The elements in the progressions are silt cover, natural vegetation (usually grasses), crop cultivation and human

Table 6 Charland population density (per sq. km).

Types of char	Years	Jamuna	Ganges	Padma	Upper Meghna	Lower Meghna
Island char	1984	233	95	126	532	281
	1993	353	89	104	731	556
Attached char	1984	455	264	312	—	—
	1993	451	261	281	—	—
Total char	1984	344	198	228	532	281
	1993	402	194	201	731	556

Table 7 Estimated charland population.

Types of char	Years	Jamuna	Ganges	Padma	Upper Meghna	Lower Meghna	Total Population
Island char	1984	104,360	9,040	3,550	26,845	31,105	174,900
	1993	174,310	12,360	7,150	33,825	100,500	328,145
Attached char	1984	203,795	39,180	10,715	253,690		
	1993	222,705	56,555	23,580	302,840		
Total char	1984	308,155	48,220	14,265	26,845	31,105	428,590
	1993	397,015	68,915	30,730	33,825	100,500	630,985

settlement. Given the vagaries of river morphology, any progression can be aborted at any point. Settlements are set up on a temporary basis as people wait to see whether their islands would survive that year's erosion.

The soil and water conditions on the chars of all river stretches (except for the northern part of the Jamuna) offer opportunities of settlement as well as agricultural activities. Except for the Ganges River, the time of the annual flood peak does not affect the Aman crops, one of the main rice crops in Bangladesh. The late flood of the Ganges (i.e. in September) affects this crop. The variation of the water levels between dry and wet season in the Ganges River is the highest, which restricts the abstraction of groundwater by hand tube-well or shallow mechanised tube-well for drinking and irrigation purposes. These two factors probably make the chars in the Ganges River less suitable for settlement than those of the other rivers. The population density in the chars of the Ganges River was found to be the lowest among the chars in the other major rivers both in the 1981 and the 1991 census.

Where soil and water conditions are favourable, char development through settlement and cultivation is constrained by the instability of chars and flood hazards. According to Schmuck (1996), erosion of the chars (Photo 1), i.e. disappearance of the char, is much more disastrous to char dwellers than floods (Photo 2). There are significant differences in the degree of such hazards faced by chars in different rivers and different stretches of the same river, thus offering wide variation in opportunities and constraints for settlement and cultivation. For example, there are few stable chars in the Jamuna, Ganges and Padma rivers, while all chars in the Upper Meghna River are very stable. But these chars are more vulnerable to flooding than those of the other rivers. These stable chars offer better opportunities to settle in, and the population density there is more than two folds higher than on the chars of the other rivers.

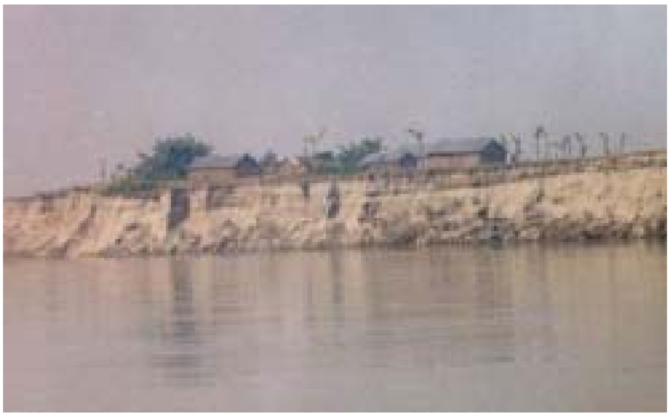

Photo 1 Char erosion.

Photo 2 Flooding of a homestead in the char.

The typical patterns of physical development and human land use differ from one reach to another and among the four rivers surveyed by the inventory. However, the river wise relevant information is presented in Figure 9 and Table 8.

In the Jamuna River, the majority of chars (56%) are settled and cultivated at the same time, although many (39%) 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 the average, shorter than in the Padma or Lower Meghna river; but there are important differences between reaches within the same river. Once new land is formed within the Ganges, natural vegetation appears more slowly than in other rivers (after 1.9 years of land formation, on the average). Cultivation on the Ganges chars, however, is subsequently initiated rather rapidly, in less than two years from the time of vegetation.

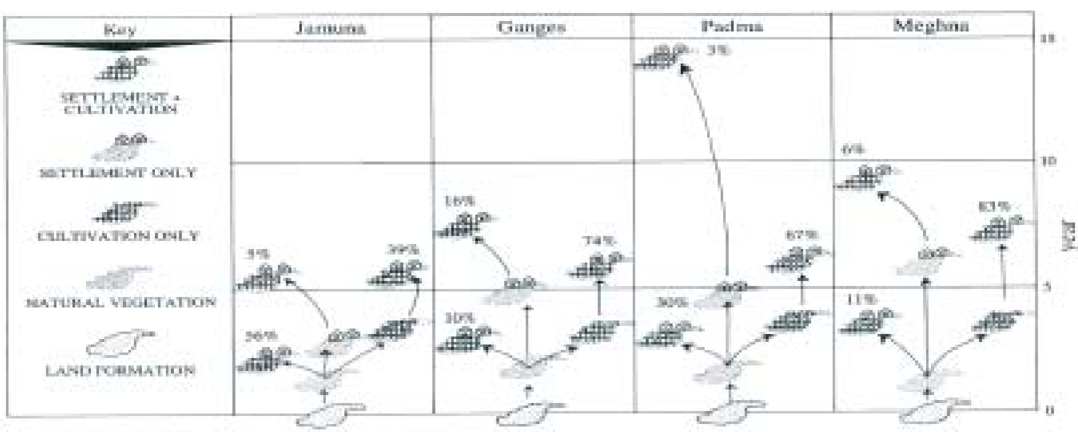

Figure 9 Evolution of chars in the major rivers.

Table 8 Average number of years taken for char development in the different rivers.

Physical characteristic	Jamuna	Ganges	Padma	Meghna
Interval Between formation and natural vegetation	1.15	1.89	1.66	1.39
Interval between natural vegetation and cultivation (no settlement)	2.29	1.78	1.95	2.3
Interval between natural vegetation and settlement (no cultivation)	1.67	3.02	3.22	4.71
Interval between vegetation and settlement-cum-cultivation	1.11	1	1.33	2.14
Interval between cultivation and settlement	1.62	2.25	2.52	3.52
Interval between settlement and cultivation	2.79	2.6	9.25	3.09

In the upper and middle reaches of the Jamuna River, 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 time required is closer to two years, as it is in the Padma River. Cultivation is initiated more quickly (about two years after the appearance of natural vegetation) on the chars at the Meghna Confluence than in the chars of either the upper or the lower reaches (3.5 and 2.6 years, respectively) of the same river.

Very few settlements in any of the rivers were established before the onset of cultivation (5% in the Jamuna; 6% in the Meghna; 3% in the Padma; and 16% in the Ganges). If this does occur, however, it takes about three years for cultivation to be initiated in the Jamuna River as well as in the Meghna River. This is as much as one year longer than it takes to move from cultivation to settlement.

7 Natural hazards

Char people are vulnerable to several natural hazards. Of these, the crucial ones are flood and erosion. They affect the lives of the char dwellers so much more frequently and intensely than the people in other parts of the country, that these hazards dominate the social and economic life of the char dwellers.

Flood

Floods are instrumental in the formation of chars. In due time the maximum elevation of chars can approach the maximum flood levels. This would imply that the younger chars would have a lower elevation than the older chars, thereby making them more vulnerable to flooding than the older chars.

Data on flood extent was obtained from the ISPAN surveys carried out in the years 1992 and 1993. For the Jamuna River, the extent of flood was assessed for the years 1987, 1988 and 1991: the flood of 1991 having been considered as average flood years, whereas the 1987 and 1988 floods were fairly exceptional. For the other rivers, the extent of flood was assessed for the period 1987–1992; where the floods occurring during 1989-1992 were averages to depict average flooding situation.

During the 1988 floods, all chars in the Jamuna, Ganges, Padma and Upper Meghna rivers were flooded. The return period of this flood was 50 to 100 years for the different rivers. The chars in the Lower Meghna River are new; no information about the inundation during the 1988 flood is available.

It is to be noted that the flood extent of the island chars of the braided Jamuna River is the same as that of the attached chars (Table 3). However, in wandering rivers such as the Ganges and the Padma, the flood extent is much higher on the island chars than on the attached chars. This supports the concept that in the Jamuna River the process of char formation of island and attached chars is the same, and different from the Ganges and Padma rivers, where island chars are younger than attached chars.

Chars in the Upper Meghna River are very old, but are more susceptible to flooding than their age would suggest. During 1989–92, 68% of the chars were inundated, which was more than in other rivers, except the Ganges. This high value may be partially explained by the high subsidence rate of this area. Besides, the fact that the low sediment contents of the Upper Meghna waters do not raise the chars by any substantial degree could be a contributing factor. The implication of all of this would be that in future flooding may increase in this area.

The chars of the Lower Meghna River south of the confluence are relatively new. During the 1989–92 floods, nearly 50% area of chars was inundated (Table 3). It is to be noted here that flood levels in the Lower Meghna River are under the strong influence of the water levels in the Bay of Bengal.

The extent and duration of severe floods, such as that of 1988, is especially threatening to char people. The danger, however, differs from river to river and from reach to reach. In 1988, almost all the island and attached chars in the Upper Meghna were flooded for 40 to 60 days. In the Lower Meghna, however, the waters widen while approaching the delta, and chars in this area were less severely affected than in the Upper Meghna. Each river showed a similarly dramatic increase over normal inundation levels in 1988 for most reaches. In the Jamuna, average flood duration was 24 days; in the Padma, 38 days; and in the Ganges, 27 days.

Flood-related deaths in 1988 were concentrated on the island chars, particularly in the Jamuna River (Table 9). Consequently, 58 percent of the reported deaths on the chars were along the Jamuna compared to a very low death rate reported for the Padma River. Unlike the cyclone-prone areas of Bangladesh, however, losses of property rather than human lives are more common and of greater significance for the riverine chars of the country.

The continuing vulnerability of char households to floods renders most families unable to make significant improvements to their lives as they find it necessary to allocate available resources to recover from the adverse effects of flood. For example,

Table 9 Flood-related deaths in the charlands during the 1988 flood.

Types of char	Jamuna	Ganges	Padma	U. & L. Meghna
		Total deaths		
Island char	416	6	6	203
Attached char	330	141	32	—
Total by river	746	147	38	203

livestock is a main economic activity, yet the number of livestock in the char areas has decreased significantly since the 1988 flood. Part of the decline may be due to losses in 1988 and subsequent floods, but most of it has been due to distress sales following the floods as people have sold cattle to raise money for other, more pressing, expenses relating to recovery from flood damage.

During floods, a large percentage of char people have only the polluted water of the river to drink since most of the hand tube wells get submerged. Since fuel is in short supply during floods, the option of boiling the water prior to drinking is not so practical (fuel is at times short even for cooking purposes). Thus, shortage of pure drinking water is a problem in chars during floods.

Coping with floods

People build homesteads on the highest available land. If they stay for any length of time in a particular place, they further elevate their dwellings on built-up plinths to avoid annual inundation. Unlike the people in the mainland, however, many char people expect to have their homes flooded every year (despite the measures taken by them to build houses on relatively high ground). If water entering the homestead is a sign of a flood crisis, such events are far more common in the chars than in the mainland.

In interviews, people explained 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 acute flood problems. As the monsoon approaches, people try to anticipate the extent of inundation mainly by listening to the radio. However, very few said this was an adequate source of information, and many said they could cope more successfully with flood if they had more time to plan for specific rises in river water levels.

One widespread pattern of flood preparation with serious negative economic consequences is the sale of cattle and other 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 of such risks were anticipated even in normal inundation conditions when settlements and grazing lands may go under water. When inundation or flood occurs, people often choose to move with their animals to higher land, often the nearest embankment. If they remain at home, many have problems caring for large animals. These animals often have to stand in water for long periods and cannot lie down because of the water that surrounds them. Under such circumstances, the animals become fatigued and vulnerable to diseases.

The problems mentioned in coping with floods on the chars are similar to those in the mainland but they are more frequent and intense on the chars. These problems include difficulties in obtaining food and supplies, and in cooking. Access to medical care is especially problematic. One Ganges charwoman, in describing the differences between char and mainland life said, ‘The worst thing about char life is women dying at childbirth because they cannot get medical attention during floods’. Health hazards related to drinking of contaminated river water are prevalent during the monsoon season and almost universal during severe floods when most tube wells on the chars are submerged.

Erosion

Land erosion is a major hazard for many of the char dwellers. The char age and char persistence analysis for the Jamuna River shows how vulnerable these chars are. Households are forced to move away from their homesteads due to such erosion. Only 40% of the char in this river persists more than 6 years (Table 5). It implies that char dwellers in 60% of the Jamuna Char have to migrate more than once within 6 years. The low flow channel migration of the Ganges and Padma rivers as shown in Figures 5 and 6 indicates that the chars in these rivers are also vulnerable. The chars in the Ganges, Padma and Lower Meghna rivers are expected to be more stable than the chars in the Jamuna River. On the other hand chars in the Upper Meghna River are much more stable.

Coping with erosion

‘We have to keep rolling like silt,’ is a saying in Kazipur quoted by Zaman (1989), who found that 20 percent of those interviewed had been displaced ten times or more by bank line erosion, and another 15 percent seven to nine times. On the island chars and adjacent mainland areas surveyed by the Jamalpur Priority Project (FAP 3.1) (Consortium Sogreah/Halcrow/Lahmeyer, 1992), 92 percent of the then char households had moved their settlements in the past, 80 percent of them more than three times and 16 percent more than nine times.

Haque (1997) mentions the three common effects of erosion-induced displacement which influenced the well-being of family members: (i) a severe cut in their standard of living, (ii) the occurrence of mental illness in the family, and (iii) the loss of valuable assets. The Flood Response Study (ISPAN, 1992) narrated numerous cases where people faced destitution due to erosion and had no alternative but to migrate away to new territory. As one group described it, ‘River erosion takes away the smiles and happiness of many people, creating unending misery. The Jamuna River flows in both their eyes (signifying tears). The char has ups and downs due to erosion, and so also do the lives of char inhabitants: many rich farmers and landlords (jotdars) of the past are now landless’. It was not unusual for adults in the Jamuna region to have moved six to ten times in their lives. One man interviewed in the Meghna Confluence had moved 11 times in 21 years (between 1969 and 1989). On the chars within the Ganges and the Upper Meghna, however, the RRA team found that fewer moves, four or less, were typical of the life histories of adults.

Most, though not all, of the people interviewed by the RRA team had lived on chars for several generations. If they had moved, it was within groups of local chars. Available data from the Flood Response Study (ISPAN, 1992) and Riverbank Erosion Impact Study (Elahi *et al.*, 1991) indicate that such moves are within small areas, usually about two miles or less. Of the 89 erosion-affected households interviewed by the Flood Response Study in two villages (one in middle reach of the Jamuna River and one in the Padma River) who had moved recently due to erosion, only seven households reported to have migrated distances of more than two miles (Elahi *et al.*, 1991). It is important to note, however, that this study of erosion-related displacement and resettlement has focused on people who remain within chars rather than on the large numbers who have left chars to live in urban slums, on embankments, or in other distant places. The generalization about migration distance therefore should be qualified: it applies to those who migrate somewhere within their original region.

Although people interviewed by the RRA teams are not clear about relations between flood and erosion, they consider the monsoon season and its aftermath as a transition point in char life when many people are found waiting to see how their land survives. In other words, they wait to find out whether they will have to move out of their own areas or not. Many people reported that they would not invest much effort or money in building their homesteads until after the monsoon season, when they would know whether their island was still there.

Social conflicts

Settlement and ownership right over the accreted land in the chars have always been complicated by the difficulty in ascertaining ownership of new land, whether it should belong to the state or to some other riparian proprietor upstream or even to somebody on the other side of the river. Although, the Ordinance of 1975, an amendment of the Act of 1950 brought about by a Presidential Order (No. 135) in 1972, provides that 'all newly emergent lands previously lost by dilution should be restored not to the original owner but only to the government', the people of the chars find it very hard to accept 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 land less and marginal farmers, in reality it has not worked in that way. Locally powerful 'jotedars' get control over accreted land through means of power and violence (Haque, 1997). This way of taking over control of the land often creates violent clashes.

Zaman (1987) reported 40 cases relating to land conflict and organized violence in char villages, stories which appeared in a daily newspaper over a period of five years (1978–1982). These cases had occurred both in riverine and estuarine chars. A total of 733 persons reportedly died in this period during the clashes for the newly accreted land. According to Zaman 'the extent of brutality and terror can not possibly be described unless some one has lived and experienced it in char life. It is different and difficult life out there'.

8 Aspects of livelihood

Economic activities

As in other parts of rural Bangladesh, the main occupation of most people in the chars relates to crop agriculture. The intensity with which agriculture can be pursued on a char depends very much on the stage of its development. As discussed earlier, some of the chars may be cultivated without having human settlements on them, particularly in their early stages. Like in the mainland of Bangladesh, rice is the main crop, which is cultivated in three seasons: Aus (April–July), Aman (August–November) and Boro (January–April). No irrigation is required for Aus and Aman, but for Boro irrigation it is often required depending on the variety and location of the cultivation. Rabi crops (from December to March) include pulse, wheat, groundnut (Photo 3), chilli etc., for which irrigation is required. Both surface and groundwater irrigation is practised depending on the availability of surface water on the char. Although catkin grows naturally, char-dwellers often plant catkin as it is a source of cash as well as household use. Moreover it encourages siltation on the chars.

Farming occupations include owner cultivation as well as sharecropping. Wage labour is also used in various agricultural operations. Absentee ownership of land is common on some chars. In certain areas, the absentee landowners have control over cultivable khas (public) land as well. Under such circumstances, relatively higher dependence is observed on tenant farming. Those who are involved in agriculture may cultivate their own land part of the time and supplement their income with day labour or other activities.

In some chars, fishing is the primary occupation for many households. In the study locations of the Upper Meghna, Meghna Confluence, and the Padma, more than 40 percent of the households reported fishing to be their primary occupation during the wet season, and many relied on fishing for income year-round (Table 10). Fishing was not a major occupation in the Ganges

Photo 3 Rabi crops – ground nut and wheat on a char of the Jamuna River

Table 10 Fishing as main occupation in chars (percentage of households).

River reach	Island char	Attached char
Upper Jamuna	02	03
Middle Jamuna	08	10
Ganges (Middle)	07	02
Padma (Middle)	23	19
Upper Meghna	15	17
Meghna confluence	28	18

Source: ISPAN, 1995.

and the Jamuna. The difference in the extent to which fishing is the main occupation depends mainly on the availability of fish in nearby rivers. Relevant data on fishing as the year-round main occupation are presented in Table 10. In addition to those whose primary income comes from the fish resources of the rivers, many others fish on a subsistence basis. In certain areas people fish as the 'last resort' activity (for example, when they lose their land to erosion). Even under normal circumstances, the primary occupation of one season can become the secondary occupation of another season. In the Upper Meghna and Meghna Confluence areas, many of the char people are found to be involved with agricultural work during the daytime and fishing during the night.

Rearing of cattle is an important source of income for many char households. Some chars, as previously noted, are endowed with wide expanses of grazing lands. When char people have relatively easy access to cattle markets, the frequency of cattle raising as an economic activity goes up. In addition to selling cattle, selling cow's milk can be an important money-earner. The milk is collected in most chars by one or two households known as *goalas*, who sell it to milk traders in the semi-urban or urban markets. Sometimes people from outside come to the chars to collect milk.

Some char people are found involved with the trading of miscellaneous commodities. They travel far and wide from their chars in search of buyers. Petty trading of miscellaneous domestic consumables is common among households living on chars that are in close proximity to towns. This kind of petty trading is more commonly found on attached chars than on island chars. The major reason for this is the better access to main land markets enjoyed by the people of the attached chars as compared to those living on island chars.

The occupational pattern of people living on chars is influenced by the nature of the labour market in other parts of the country. Wage labouring in agriculture does not necessarily mean that one has to be confined to one's immediate neighbourhood. Many people from numerous chars migrate seasonally to other areas in search of agricultural work.

Char dwellers also work as unskilled labourers on mainland earthwork projects, and some have traditionally been involved in specialized mainland occupations. Some of these people, when affected by erosion, were able to move their entire families to the location of their jobs. Although most of them have moved their families back onto their own land when it resurfaced, some managed to keep together in the mainland, which is their preferred option.

Occupations of char people are affected by the cycle of emigration and immigration triggered by events of erosion. Frequent migrations may entail unemployment for some people and can result in quick occupational changes. Much depends upon the options that are available. Options available to erosion-affected households vary quite significantly with their socio-economic standing. A char household prefers to own land on more than one char in the hope of having a place of its own to move to in the event of its homestead, located on one specific char, becoming victim to erosion. Many households, however, cannot afford such 'portfolio-diversification'. Therefore, erosion may turn a land?owning farmer into a landless day labourer, causing him to move to some other char or some part of the mainland in search of employment as wage labourer.

Market orientation

As in other parts of Bangladesh, the people living on chars are quite heavily dependent upon markets. It is true that some chars are rather remote from urban areas, and people cannot easily access mainland markets from there. However, many char dwellers go to mainland markets once or twice a week for selling or purchasing different kinds of merchandise. People living on chars that are clustered within an area far away from mainland markets at times set up their own marketplace on one of the relatively stable chars. Although such small markets cannot be substitutes for the mainland markets, they act as secondary markets for the people concerned and are important during emergencies. People who find it too expensive to carry merchandise to distant mainland markets often bring goods to such local markets to be sold to the visiting middlemen.

The char people sell various agricultural crops in the market. They have to frequent the markets for purchasing consumption essentials, implements and various inputs used in the production process. Most char people find it relatively easy to visit the marketplaces during the monsoon when the river channels leading to the markets are navigable. Floods during the monsoon can, however, make boat journeys to the markets quite hazardous, and inundate some of them as well. Under such circumstances, some trading continues on boats in certain weekly and bi-weekly marketplaces. Access to distant markets during the dry season can often be very difficult for char people when the only way to reach them is by walking. Walking long distances on sand are both tiring and time-consuming, particularly when bulky items have to be carried.

Health, sanitation and education

As in other rural communities in Bangladesh, health and sanitation services are in short supply in the chars. The cost of medical care available in the mainland proves prohibitive for most char dwellers. Only during serious emergencies would they try to obtain such services. In most places, diseases associated with the normal monsoon cycle are reported to be a greater cause of death than severe floods.

While there are primary schools on many chars, the coverage is much less than the national average. The situation is rather precarious in some of the relatively remote island chars. Even where there are educational facilities, keeping children in school during the monsoon season or during problems caused by erosion is a difficult proposition.

9 Considerations on management and future developments

The study of EGIS (2000) contributes to the awareness of both the need for and possibilities of improving the livelihood conditions of char dwellers through management interventions that would enable them to better cope with the hazardous environment. It was recommended that a special Char Program Development Committee (CPDC) would be established that focuses on the unique characteristics of the chars and has the mandate to develop special program interventions. Examples refer to such issues as: settling confusions and conflicts on administrative boundaries; development of proper land laws and their enforcement; use of public land; flood and erosion prediction and warning mechanisms; planning for and supporting the provision of better basic services (agricultural extension, health and sanitation, education, public transport, institutional credit); and assistance to flood and erosion affected people.

In further developing special purpose management arrangements, long-term physical and economic developments have to be taken into account. The following merit mention:

- In the recent past, the river and char morphological processes might have been more dynamic than usual as a result of the 1950 Assam earthquake and it is expected that the high annual widening rates of 160 to 250 m measured in the past decades will slow down in the coming decades. This contributes to the expectation that the total char area is likely to increase in the next decade and that chars might become more stable.
- Expectations on other long-term developments are less positive. Particular reference is made to the possible impacts of climatic changes and consequent sea level rise. Sea level rise, for example, might result in increased flooding of the chars in the Upper and Lower Meghna rivers as well as the Padma River. More uncertain, but also more important, might be the expected growing instability of the chars due to the predicted increase in the variability of the extreme high and low values of water levels and flows.
- Char economics have become more market-responsive than they used to be. This trend of a more market-oriented economy has been observed in many rural areas of Bangladesh, creating opportunities for diversification (of employment for example) that would enhance endeavors to improve livelihood conditions.

It is strongly felt that the above changes will provide good opportunities to improve the livelihoods of the hundred thousands of char dwellers. This would require a firm commitment of the Government of Bangladesh and strong institutional arrangements.

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