BANGLADESH FLOOD ACTION PLAN

Ministry of Water Resources

Flood Plan Coordination Organization (FPCO)

The Dynamic Physical and Human Environment of Riverine Charlands: PADMA

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 report is one in a 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. This report covers part of the work of Phase 2 of ISPAN's resource inventory of riverine chars, the charlands of the Padma River. It includes a summary of the river's recent morphological changes. This was based on satellite images from 1984 and 1993. The study was carried out by ISPAN under Flood Action Plan Supporting Studies FAP 16 (Environmental Study) and FAP 19 (Geographic Information System). The first phase of the study (the Brahmaputra-Jamuna) started in early 1992, this phase was undertaken in 1993.

There are two major data sources: a field inventory of resources and satellite image analysis. The field inventory was developed by using a questionnaire to interview key informants in charland areas. The inventory was carried out by Development Planners and Consultants (DP&C) under contract to ISPAN. The image analysis, which was done by FAP 19, consisted of developing and analyzing maps of land use and changes in the physiography of the land. A socio-economic component was added to the study in 1993.

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 Keith Pitman, Chief of Party, ISPAN. It has depended heavily on field work undertaken by about 16 enumerators organized through a field work 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.

We are grateful to the Flood Plan Coordination Organization and to its Panel of Experts for providing overall direction to this study.

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
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 School 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 spontaneum*) giving 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 Development 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
suji	-	An improved variety of *kaon* (fox-tail millet)
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
PADMA

The residents of chars and the mainland adjacent to main rivers 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. Reliable information about these areas and the people who live in them has always been scarce. The limited accessibility of 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. 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 these perilous lands.

"Charland" is the Bengali term for a "mid-channel island that periodically emerges from the riverbed as a result of accretion" (Elahi, Ahmed, and Mafizuddin 1991). For this study, the definition was widened to include areas of erosion and accretion along the banks of the river. Land, which was studied on mauza level, was classified as follows:

- Island chars.
- Right and left bank attached charland.
- Right and left bank setback land.
- Right and left bank unprotected mainland (other than setback land).

The figure below illustrates this classification system. For this study of the Padma, charlands that are separated from the mainland by small channels (by former distributaries of the river, for example) have been classified and treated as attached chars.

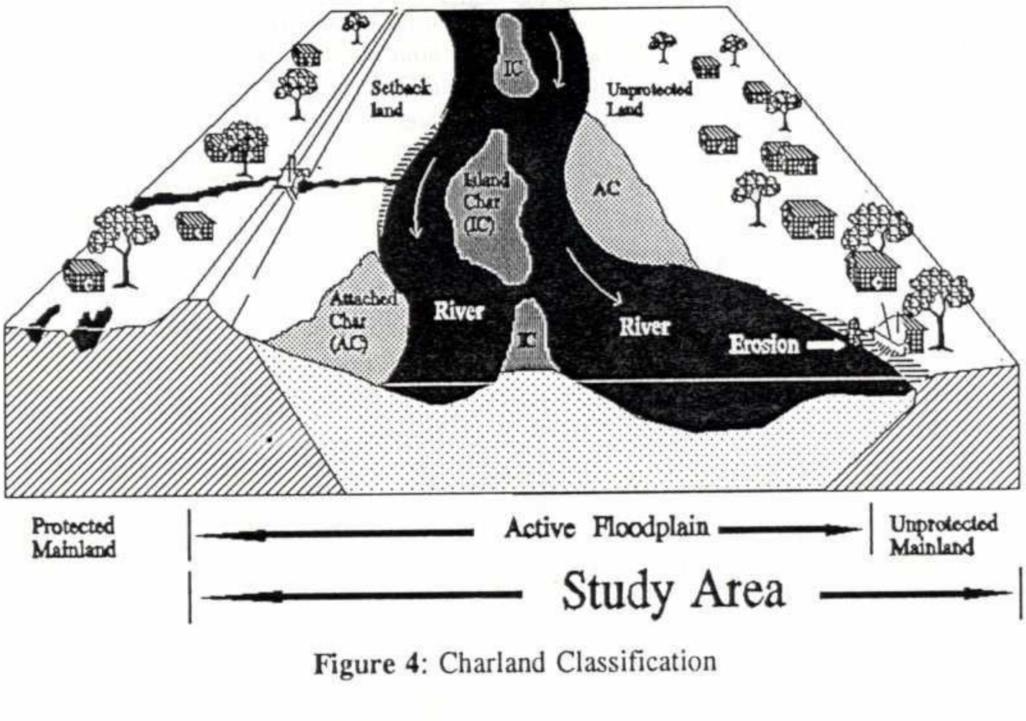


Figure 4: Charland Classification

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. This study excluded the Meghna confluence, which was examined as part of the Meghna Inventory study area. The Padma study area, then, is only some 84 km long, but despite its small size, it is one of the most dynamic areas of riverine charland in Bangladesh.

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 flow. 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, and the river's alignment has remained the same since then, although the river channel has progressively widened.

The Padma, as previously mentioned, is a highly dynamic system. It carries the highest sediment load in Bangladesh, and has a total catchment of some 1.7 million km^2, comprising the combined catchments of the Brahmaputra and Ganges. It is fed by runoff from the highest, most tectonically active mountain range in the world, the Himalayas. Young alpine mountains like the Himalayas are naturally subject to severe erosion, and as a result, the Padma carries a very heavy sediment load. The highest estimates 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. Typically, it alternates between phases when meandering predominates 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 it formed. 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 than this: in Sadarpur (right bank) 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.

Tables 1, 2, and 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

Table 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 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 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 km^2 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.

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 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.

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 day labor, which is predominantly agricultural. The Padma is an important riverine fishery, although much less important 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 earning 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.

Floods are the main natural hazard faced by char dwellers. In 1987, 71 percent of cultivated land 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 same areas that reported the most flood deaths.

The provision of services and infrastructure is the key to improving the live of char people given the hazards with which they live. Study area health care facilities are concentrated in the unprotected mainland. In the Padma charlands, coverage by health workers is comparatively good, and there are a reasonable number of health care facilities, although they 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 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.

This is the first study to collect data for the whole of the Padma charlands. The inventory data and Geographic Information System (GIS) that have resulted from this study offer a means of directing development programs to likely priority areas in terms of service provision and program location. The maps that form the core of this report already draw attention to high-priority needs. More detailed assessment using the GIS would assist in local planning and directing needs assessment to the areas with greatest hazards and least services.

Several planned or proposed interventions may affect the Padma charlands. Flood proofing measures, such as shelters and emergency transport services, could assist people in coping during severe floods. In addition to programs directed specifically at charland hazards, there is a more general need that government and non-government development work give proper attention to the charlands, and that planning and service provisions be appropriate to the charland environment and society. Improved crop and livestock farming, for example, could involve research and development on dry-land farming, irrigation in chars, and livestock cooperatives or groups to improve access to credit and transport. In most of the area, however, erosion risks are high—maybe higher than perceived in the past on attached chars—so structures built in the Padma charlands should be movable.

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). It is likely that an additional 30 cm of flooding 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 1

INTRODUCTION

1.1 Background to the Study

1.1.1 History

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 (see Section 1.1.4). In addition, FAP 14, the Flood Response Study, carried out socioeconomic 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.

1.1.2 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).
- 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 is the report of the second stage of Phase 2 of the FAP 16/19 Charland Study: the Padma charland inventory. It consists of analysis, maps, and summary data tables dealing with population, land and resource use, and hazards for each mauza.[1] (Notes follow each chapter.) Satellite images and analysis of changes in the Padma River course and chars are also included.

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. Some of the more important results from the inventory and the GIS concerning human population, resources, and hazards appear as figures in this report.

1.2 The Padma Study Area

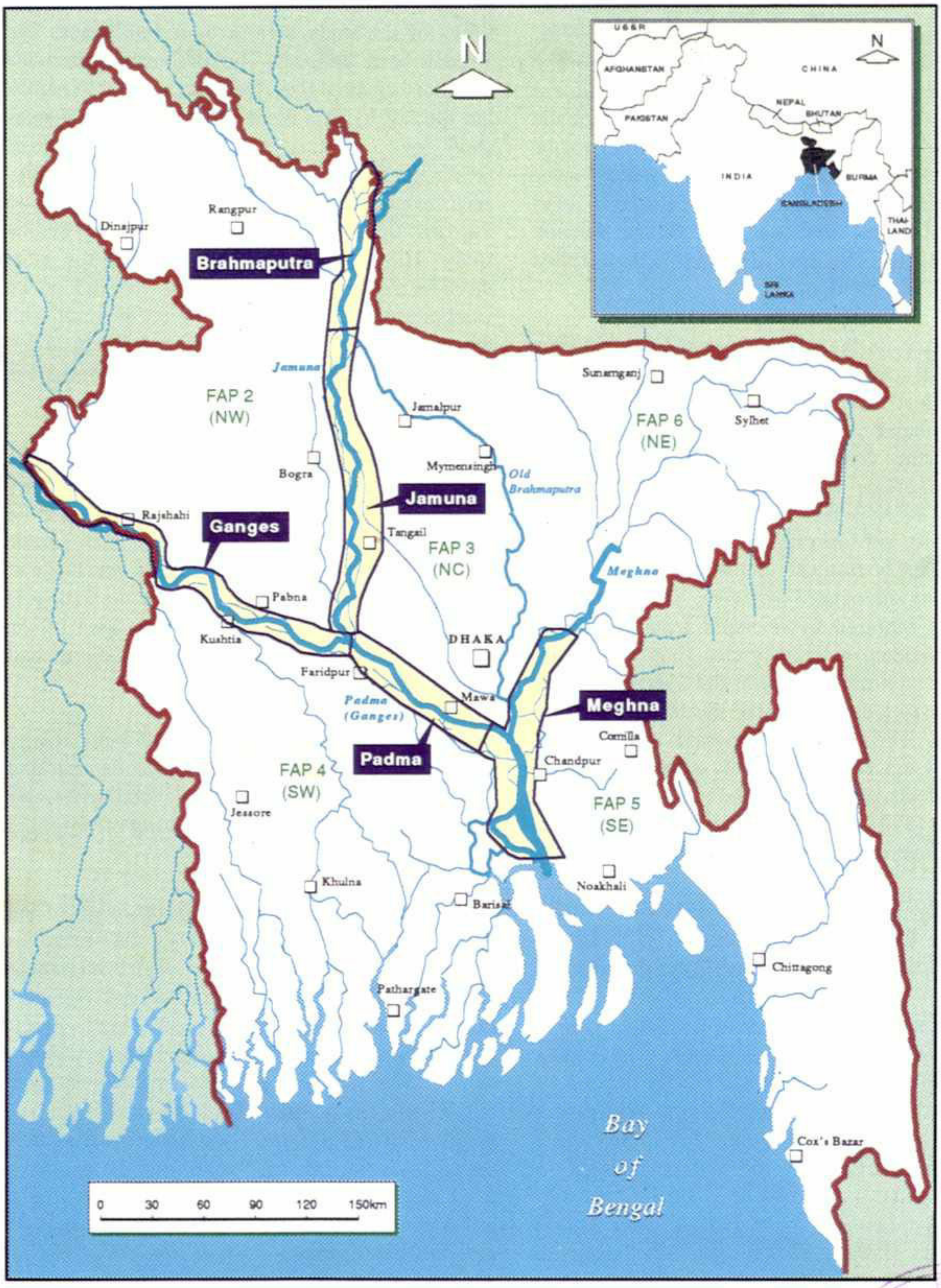
1.2.1 Delineation of Study Area

The Padma (pronounced *Podda*) River (Figure 1.1) is the shortest and newest component of the Ganges-Brahmaputra-Meghna delta. It is not a true river but, rather, a single channel connecting other rivers. It flows from the confluence of the Jamuna and Ganges to the confluence with the Meghna, below which the combined flow of all the rivers is known as the Lower Meghna.

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 1770 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

Figure 1.1

Charland Study Location



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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 the harder Chanida 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 distributary, and the combined Ganges-Jamuna flow passes through the Padma to join the Meghna just north of Chandpur.

In summary, in the past 200 years the main flow of the Brahmaputra moved 60 km west; the Upper Meghna lost much of its flow south of Bhairab Bazar; a major new river, the Jamuna, was created; and the Ganges and Brahmaputra-Jamuna joined to create the vast new river called the Padma. This river then moved northeast to capture the Meghna and form the present Lower Meghna. These changes resulted in the Madhupur Forest Tract being surrounded by rivers. The Dhaleswari flow was captured by overspill from the newly formed Jamuna, effectively changing the Dhaleswari's being a distributary of the Ganges flowing northeast, to a distributary of the Jamuna flowing southeast. Throughout this period, the Ganges' main flow moved progressively eastward, leaving moribund distributaries in the southwest region. Between 1830 and 1857, the Ganges ceased to have a direct outfall to the Bay of Bengal.

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. The Padma channel is relatively recent and clearly defined by the two confluences at either end of it. While there are large island chars in the Padma, the active floodplain is extensive and the main issue in delineating the study area was the limit of this active floodplain. Survey of Bangladesh 1:50,000 scale maps, 1989 1:50,000-scale SPOT satellite images, and the 1993 Landsat image were used to determine the study area.

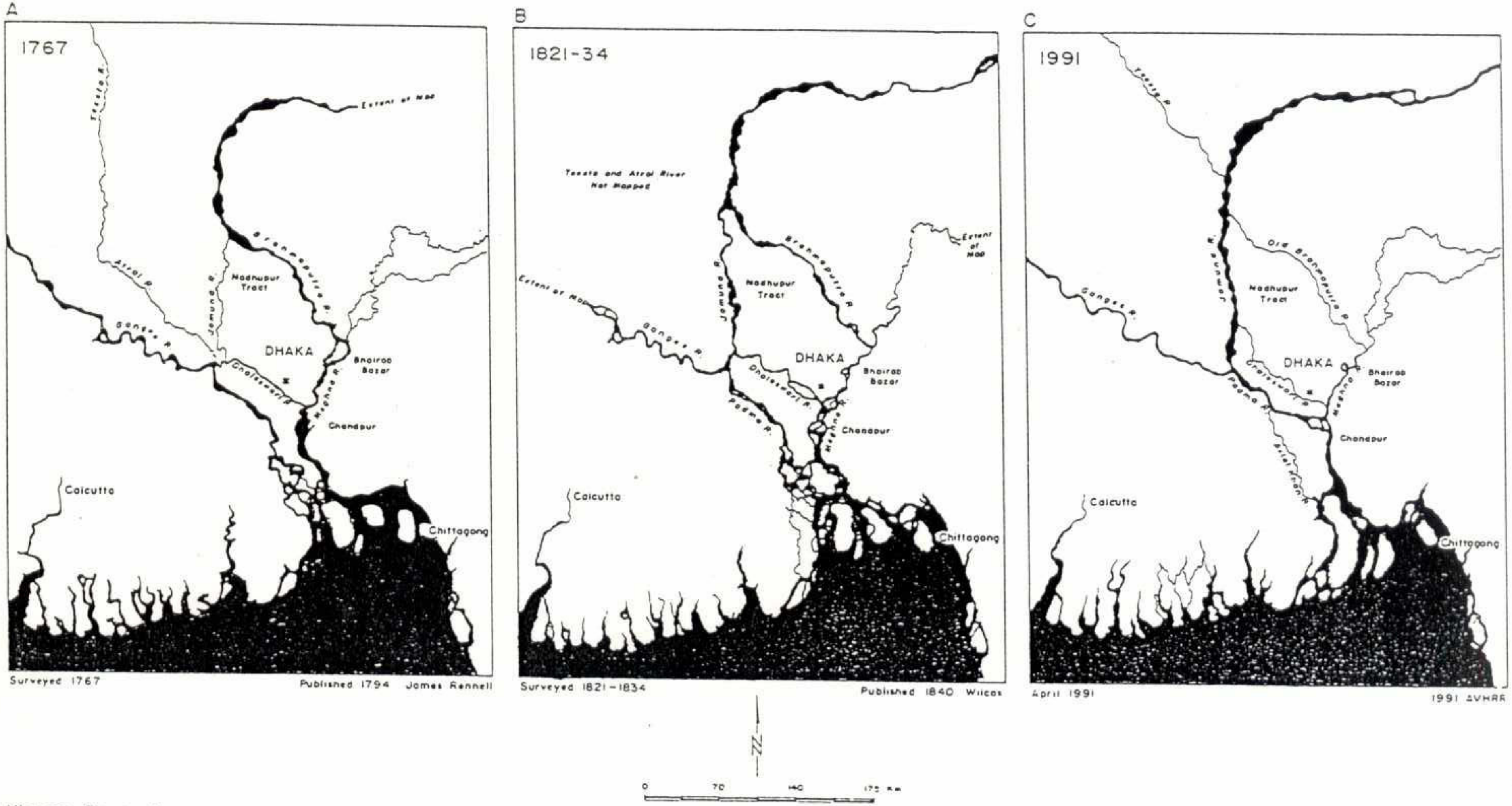
The charland inventories of the Jamuna and Meghna were started before that of the Padma, so the limits of the study area at both confluences had already been defined. The Brahmaputra-Jamuna inventory covered that river's west and east banks, but did not include the south bank at the Ganges confluence. Because the attached charland of Goalando Thana, on the south side of the confluence, extends a short distance up the Ganges into Rajbari, this area was included in the Padma study. The Jamuna study area extended the same distance along the north bank, so the end of the Ganges study area was aligned north-south with the western limits of the other two study areas. The Padma study area, therefore, is contiguous with the Jamuna study area.

The Meghna study area included the whole of the Padma-Meghna confluence. The complex of very mobile island chars at the confluence needed to be surveyed and reported as a whole and so the division between the two study areas was made at the furthest point downstream where the Padma is a single narrow channel, just to the west of the Chandina Alluvium outcrops in Lohajong and Zanzira thanas (Figure 1.2).

The 1993 charland surveys used the methodology developed for the Brahmaputra-Jamuna charland inventory. The study covered all land and water along the Padma River up to existing or proposed embankments.

Along the west or south bank (right bank) of the Padma there is almost continuous flood protection comprising both BWDB and local government embankments. FAP 4 has surveyed this embankment, and a copy of this map was used to delineate the study area. During the inventory fieldwork it was apparent that this embankment was not fully effective—the Arial Khan off-take remains open and permits flood water to pass into the adjacent floodplains. Regardless, the embankment was treated as though it was effective, and the alignment was used as the study area boundary. In Char Bhadrasan, where there is no sealed embankment, the study area was extended as far as other flood-limiting features such as roads. This

EVOLUTION OF THE RIVER SYSTEM OF BANGLADESH



Historic Figure I

ISPAN FAP 19, Geographic Information System

PADMA STUDY AREA
BASE MAP

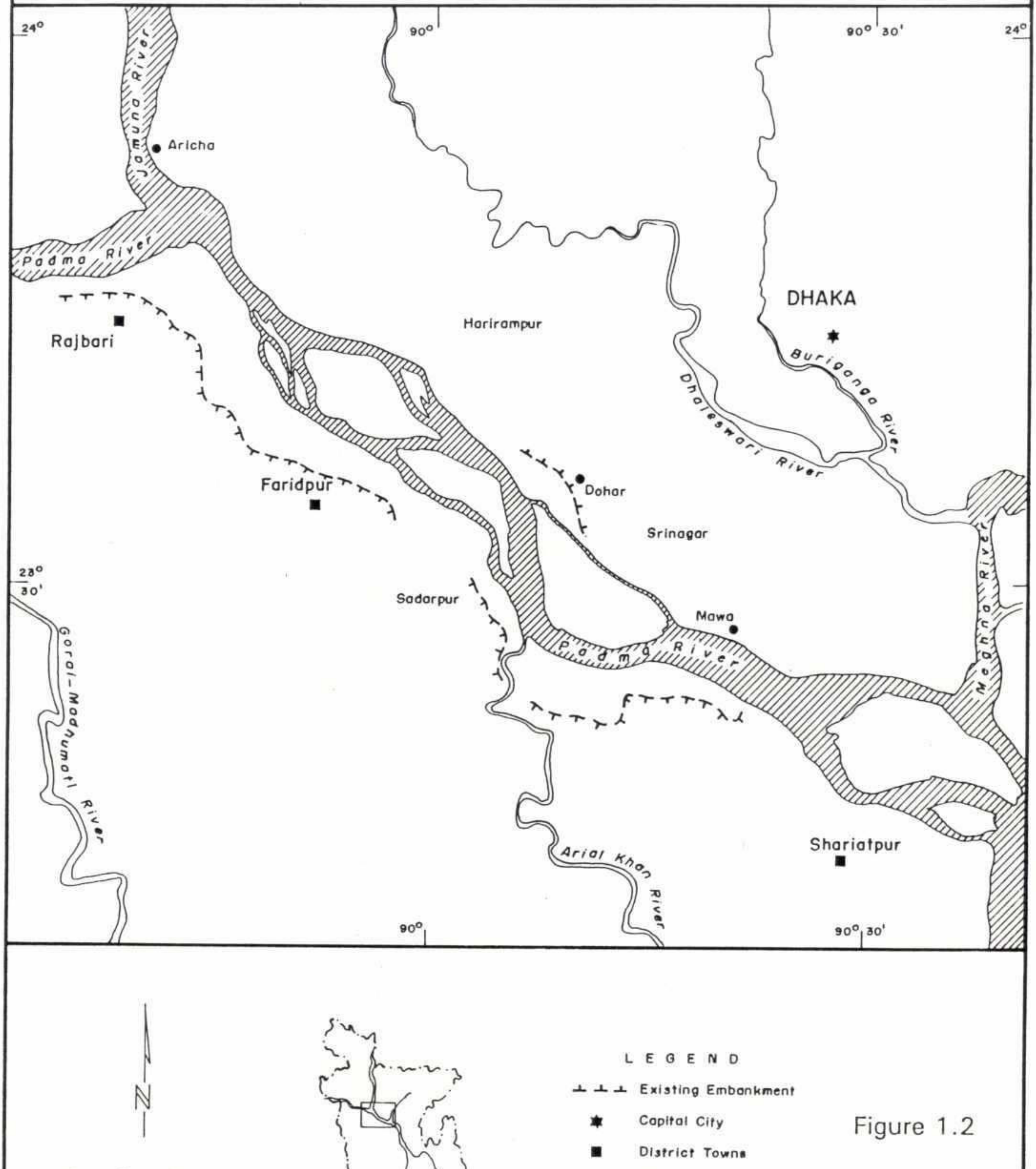


Figure 1.2

ISPAN FAP 19
Geographic Information System

area was noted as affected by flood spills in FAP 25 (1993). Figure 1.3 shows the extent of the study area by thana.

FAP 3 has proposed embankments on the east or north bank (left bank) of the Padma. In Dohar Thana there is already a limited length of flood protection embankment which forms the study boundary. Elsewhere, roads following the river-side were taken as approximate boundaries since any flood protection embankments will likely follow their alignments. Where no embankment existed the study area boundary was adjusted to follow mauza boundaries in order to simplify data collection for the Inventory Surveys. Thus, parts of mauzas which might be split and protected by new embankments were included in the study.

The study area was divided into three reaches coinciding with differences in the char land types. The upper reach, which is a single channel, covers the Jamuna confluence as far as Faridpur. The middle reach, where the channel is divided and shows signs of braiding, covers two large island char complexes. The lower reach, downstream from Sadarpur, has experienced the greatest changes in course; between 1984 and 1993 a large meander developed in this area, which includes one large newly accreted char. To facilitate use of the inventory, union parishad boundaries were followed in defining reaches.

1.2.2 Links with Other FAP Studies

Two FAP Regional Studies bound the Padma charland study area. These studies provided the FAP 16/19 study with the following information:

- North Central Regional Study (FAP 3)—proposed embankment alignments along the north bank of the Padma; and
- Southwest Regional Study (FAP 4)—survey of embankments along the south bank of the Padma, historic maps of the river system, and information and analysis of the river's morphological changes.

Neither of these FAP studies have proposed structures in the charland study area, and there has been little discussion of alternative measures, such as flood proofing, for the Padma charlands.

In addition, the Flood Modelling and Management Study (FAP 25) provided details of flood levels and return periods at gauging stations along the Padma.

Potential further uses and users of the Padma charland inventory data and GIS are discussed in Chapter 5.

1.3 Inventory Methodology

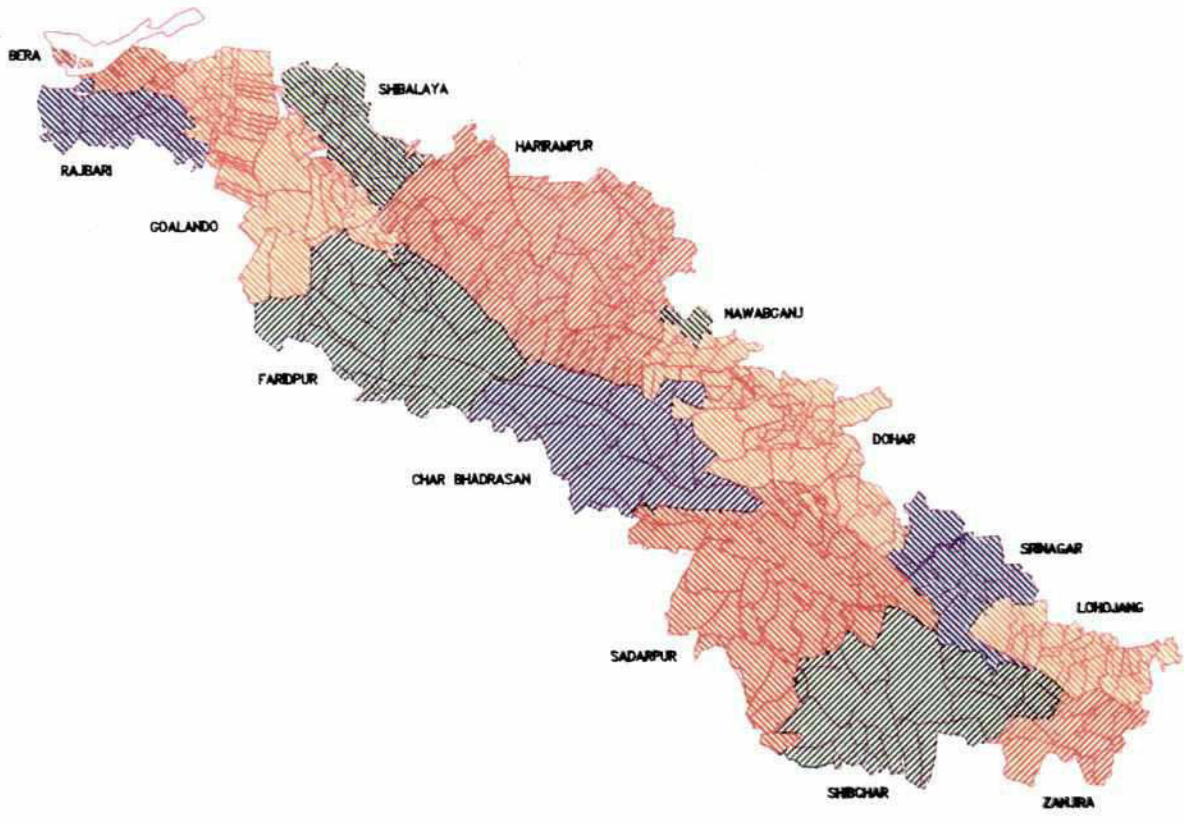
1.3.1 Overview

The FAP 16/19 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 displays the field data as digital maps. The methodology for the mapping and field surveys evolved from the experience of the Brahmaputra-Jamuna Charland Study. The methodology followed is summarized in this chapter, as are specific issues raised in the Padma charlands.

The inventory used an iterative process of refinement using maps, images, fieldwork, and questionnaire data; generally the sequence was as follows:

- defining the study area (Section 1.2.1);
- 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

Padma Reach Thanas



NUMBER OF MAUZAS
UNDER EACH THANA

District	Code	Thana	No. of Mauza
Dhaka	3018	Dohar	64
	3028	Harirampur	91
	3044	Lohojang	28
	3062	Nawabganj	5
	3078	Shibalaya	39
	3084	Srinagar	13
Faridpur	4021	Char Bhadrasan	15
	4029	Goalando	86
	4047	Faridpur Sadar	31
	4076	Rajbari	23
	4084	Sadarpur	37
	4087	Shibchar	29
	4094	Zanjira	11
Pabna	7016	Bera	13
Total Mauza			485

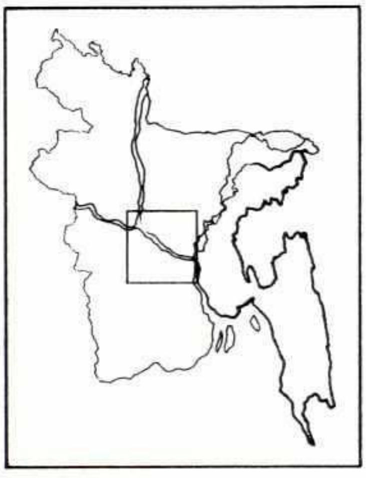


Figure 1.3

FAP-19 Geographic Information System

to study area boundaries and additional information from field teams; and
- tabulating, analyzing, and mapping data.

1.3.2 Charland Classification

Land and mauzas in the study area 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 1.4 illustrates this classification system, which was developed for the Brahmaputra-Jamuna charland inventory.

For this classification, island chars are defined as land that, even in dry season, can only be reached by crossing a main channel of the river. Attached charland is accessible from the mainland without crossing a main channel during the dry season (although 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 features, such as roads, that restrict flooding.

In the Padma charlands most unprotected mainland is setback land or will become so if proposed embankments are completed, but for consistency with the other charland inventory reports the term unprotected mainland is used.

Embankments rarely if ever follow mauza boundaries. Where mauzas were split by an embankment the respondents were asked to give inventory data only for the unprotected part of the mauza. This resulted in a more accurate assessment of the study area population, resources, and hazards and avoided the problem of estimating the proportion within the unprotected area. The 1981 population figures for those mauzas have been apportioned according to the area of the mauza's unprotected and protected land.

Distinguishing between island and attached chars proved difficult in the Padma charlands. Large parts of the west bank attached charland are

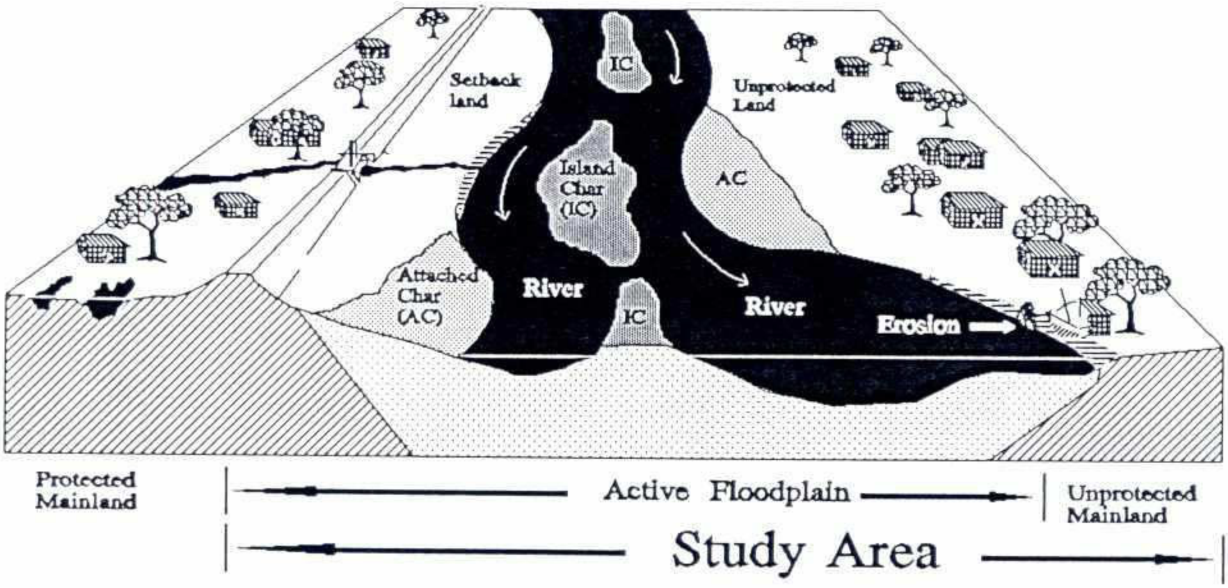


Figure 1.4 Charland Classification

separated from the mainland by substantial channels that are navigable year-round. These are not part of the main channel but, rather, smaller rivers now intersected by the Padma. Treating these areas as island chars would have complicated the analysis of bankline erosion impacts since they are clearly outside the present banks of the Padma. The same argument might have been applied to the large island char on the boundary of Srinagar and Shibchar thanas, but this land has accreted as the main river channel eroded southward and so is relatively recent. It is also separated from the mainland by a channel that was once the main dry season course and now carries a substantial part of the Padma's monsoon flow. The charlands are a changing environment, so these areas might, after further erosion and accretion, be categorized differently in the future.

The breakdown of the study area into this classification system is shown in Chapter 3 (Figure 3.1), where it is compared with a land use classification derived from satellite image analysis.

1.3.3 Mauza Mapping

In order to collect and present the mauza inventory data, a suitable map base was required on which output maps from the GIS could be produced.

One existing set of maps, scaled 1 inch to 1 mile and known as Police Station maps, shows the location of mauza boundaries. Along the Padma these maps were mostly surveyed in 1911-12, and corrections were made in the 1930s, but several were surveyed between 1941 and 1945. For this study, the mauza boundaries, including latitude and longitude marks, were traced from each of these maps onto separate acetate sheets. These maps were then compared with the relevant BBS Small Area Atlases to determine mauza "geocodes," which were used to identify mauzas, and any recent changes in mauza boundaries.[1] (Notes follow each chapter.) The tracings were then digitized. In the GIS the thanas were joined, and boundaries were matched. Small gaps and overlaps between mauzas along the edges of thanas were corrected by taking a middle line. The few larger areas that had not been allocated to a mauza at the time of the Police Station maps and were not shown as belonging to a mauza in the Small Area Atlas were then highlighted for field checking.

The locations of existing and proposed embankments were traced onto separate acetate sheets directly from the 1989 1:50,000 SPOT image sheets. The alignment of existing embankments was generally very clear on these images, but when there was any doubt about a location, Survey of Bangladesh 1:50,000 maps and maps from relevant FAP regional studies were consulted. Maps of existing and proposed embankments provided by FAP 3 and FAP 4 were used.

Where there was no embankment or proposed embankment, the physical boundary closest to the main river channel was used. The resulting study area boundary was digitized and overlaid on the mauza map, and the boundary where there was no embankment was revised to include mauzas intersected by the boundary line. The study area boundary, then, follows mauza boundaries except where there are existing embankments.

The mauza and study area boundaries were then overlaid on the January 1993 Landsat image of the Padma. A series of overlapping color prints of this combined map were made at 1:100,000 scale, and a transparent overlay, with the geocodes for each mauza, was added. A large plot of the mauza boundaries in the study area, also at 1:100,000 scale, and a copy of the relevant pages of the Small Area Atlases, with study area mauzas highlighted, completed the set of fieldwork information provided to the interview teams.

Field teams were given a color image of their areas, as well as black-and-white photocopies of the image and a mauza boundary map. The teams were required to visit each mauza in the study area, check on the status of areas not allocated to a mauza or where boundaries were uncertain, and complete additional questionnaires as appropriate. Relevant thana officials provided information on present administrative boundaries and recent changes.

1.3.4 Inventory Questionnaire

Field data collection used a key-informant interview method following a fixed questionnaire in each of the study area mauzas. First, the mauza was identified and located on the image, the name was checked, and key informants, or individuals who could speak for the entire mauza, were identified. If such informants could not be found, then separate returns were completed for the mauza's constituent villages. In the Padma study area there were only 19 mauzas where two inventories were completed (split between island char and setback land).

The questionnaire was a modified version of the one used in the Brahmaputra-Jamuna inventory. Based on past experience some parts of the questionnaire were simplified, and more questions on hazards, including some on agriculture and others on flood and erosion impacts, were added. The questionnaire is reproduced in Appendix A.

The questionnaire was pre-coded and consisted of about 450 discrete pieces of information covering the following issues:

- Identification of the mauza.
- Physiography of the mauza.
- Mauza population, including seasonal and permanent in- and out-migration.
- Infrastructure and service provision.
- Broad socioeconomic parameters (occupations, agriculture, livestock).
- Environmental hazards.
- Social conflicts.

1.3.5 Fieldwork and Boundary Problems

The main problems arising during the inventory fieldwork involved confusion and disputes as to which mauza, union, thana, or even district a piece of land belongs. The extensive changes in course and in char formations in the Padma in recent years mean that detailed boundary surveys are needed in several places. Accurate maps, produced in conjunction with census data, are needed to ensure that the spatial content of census data is correct and that government officials and elected representatives have accurate information about their service areas and constituents.

Mauza boundaries and administration units in the study area had mostly been fixed by 1912, and since then modifications have been limited, despite significant changes in the river channel. In a number of cases the mauza boundaries reflect the river channel alignment at the time of the cadastral survey, with the main district boundary typically following what was the center of the river. In the field maps used for the inventory, uncertain mauza boundaries were identified, but the field teams were neither set up nor equipped to carry out detailed mapping, so they were rarely able to accurately identify changes to these boundaries.

The main problem area was Dohar Thana, where there has been considerable accretion and some subsequent erosion since the Police Station map of the 1930s. As the Padma moved south, some 18 mauzas were created on this accreted land. Although these are listed in the BBS Small Area Atlas, they are not shown in the map in the atlas, which is based on the Police Station map. The thana office provided a more recent map showing all of the mauzas, unfortunately this was not cartographically accurate, which limited its usefulness. During fieldwork a GPS was used to fix the location of intersections of selected mauza boundaries based on information from local people, including a local *amin* (surveyor).

Fitting these mauzas into the established jigsaw of interlocking mauzas was still problematic, and was not helped by the fact that the same names were sometimes given to adjacent mauzas of neighboring unions. In one case a mauza was reported to be within Srinagar Thana for the purpose of union parishad elections, but the land was registered in Dohar Thana. It appears, with different boundaries, in the 1981 census (BBS Small Area Atlas) in both thanas. Other areas of newly accreted charland between Dohar and Char Bhadrasan thanas appeared to be the subject of dispute between the two thanas. Mapping of inventory data in this area, therefore, is only approximate. Such confusions as were found in this area hinder efficient administration and development efforts. Accurate surveying of mauza and administrative boundaries is needed in this area of the Padma.

Two large areas within the Padma banklines, the survey found, include newly accreted charland but are not allocated to any mauza. These were reported to be *khas* land, but since people were occupying the land an inventory questionnaire was completed. Although mapped and included in the databases as separate units, these areas are not recognized as mauzas.

Other inaccuracies found in the Small Area Atlases included: mauzas that appeared in the lists for more than one thana, mauzas that were not mapped, and mauzas in the same thana with the same geocode. With the help of the local thana officials, Union Parishad Chairmen, and local people as consistent a data set as was possible was prepared. Corrections were made to the digitized maps and to the geocodes to ensure that the inventory data was accurately plotted in the maps.

These uncertainties about the location and distribution of resources (land and people) relative to administrative units are a handicap to efficient development planning. More accurate official boundary demarcation is required in the areas where this study found uncertainties and disputes.

1.3.6 Satellite Image Interpretation

The Landsat imagery analysis on char physiography is detailed in Chapter 2 of this report. This analysis has been carried out by superimposing on the January 1993 image an image from the 1984 dry season. The image analysis enabled the following to be mapped and quantified:

- Char persistence between 1984 and 1993.
- Erosion and accretion patterns over the past nine years.
- Current land use and cover.

Mauzas were categorized according to the charland types defined in Sections 1.2.1 and 1.3.2. Initially, the field teams determined for each mauza the proportions of mauza area in each category based on field observation, local information, and the 1993 satellite image. Mauzas were then categorized according to the dominant land type (excluding water areas). This was later cross-checked against the satellite images and questionnaires, and corrections were made.

In the Appendix B tables, which summarize the data by reach and char type, mauza data is aggregated according to the charland type of the maximum area of land within the mauza. The tables are analyzed and interpreted in Chapters 3 and 4.

NOTES

1. The Police Station maps, which are more accurate, remained the primary source.

Chapter 2

CHAR AND CHANNEL DYNAMICS

2.1 Summary

Seasonal and long-term changes in the geomorphic characteristics of the main river charlands affect the settlement patterns and social and economic activities of their inhabitants. To better understand the dynamic nature of the chars, FAP 19 undertook a study of satellite images. This data medium is the most effective means of monitoring present-day changes in the physical and morphological characteristics of these riparian environments.

Analysis of 1984 and 1993 satellite images confirmed the evidence of earlier maps, that although the course of the Padma has changed little since 1984, all sections of the river have been quite dynamic. The Padma is only moderately braided, so the development and evolution of its river courses and char morphology is relatively simple to track.

Since 1984 the northwestern section of the river (upper reach) has narrowed considerably while maintaining its course. The course of the middle reach has also remained stable, but has become considerably wider and had a concurrent increase in charland area. The southeastern section (lower reach) changed dramatically in width, planform, and char area. The width in this reach increased as much as 5.5 km, while both southward and northward centerline shifts exceeded 1 km. The average annual right bank erosion rate (1984-1993) in the lower reach was approximately 204 m per year. In the middle and lower reaches the area of chars has increased relative to the area of water. Char accretion in the middle reach divided the main channel in two distinct areas.

The Padma has not migrated significantly in any direction for many years, but analysis of a longer time series of images is needed to make quantitative predictions of future trends. The evidence of the past decade suggests that a predominantly meandering pattern may emerge, bringing rapid bank erosion at meander bends. The braiding intensity and width of the middle and lower reaches will likely continue to increase as floodplain is eroded. Consequently, sedimentation will enlarge existing island chars and continue to create new ones. There are stable nodal reaches at the western end of the study area south of Aricha, and at the eastern end near Mawa and Shariatput. A large meander has developed at the Arial Khan offtake, and the flow of the lower Padma could conceivably switch away from this into a minor left (north) bank channel near Srinagar.

2.2 Background

Three great rivers drain through Bangladesh and have been responsible for building the vast alluvial fan that forms its landscape. The Ganges and the Brahmaputra are the larger, both ranking among the 10 greatest rivers in the world. They both have very large catchments, only a faction of which is located within the borders of Bangladesh. The Upper Meghna is much smaller and rises within the borders of Bangladesh. The Ganges and Brahmaputra-Jamuna join to form the Padma near Goalando. Approximately 100 km downstream the Upper Meghna joins the Padma to form the Lower Meghna (by volumetric flow rate the third largest river in the world) before entering the Bay of Bengal. It is important to bear in mind the dynamic nature of these rivers over both the geological time scale and recent past when considering their present hydrology and geomorphology.

The Ganges rises in India, on the southern flanks of the Himalayas and flows southeastward into Bangladesh. Until about 500 years ago it followed a course well to the west of its present position in Bangladesh, building a delta in the area of Jessore and reaching the Bay of Bengal along the course of the present Hoogly River. In the 15th or 16th century it began to swing eastward to follow a course close to that of the present day Gorai River, and the Hoogly became a right bank distributary. It then continued to migrate eastward, and by the mid-18th century Rennell's map shows it flowing along what is now the Arial Khan (see Historic Figure I). Until that time, there had been no confluence of the Ganges with either the Brahmaputra or the Meghna, but this situation was to change radically in the next few decades.

The Brahmaputra rises on the northern flanks of the Himalayas, its source only a short distance from that of the Ganges. It flows almost due east through China as the Tsangpo before turning south and entering India. It then flows southwest through Assam as the Brahmaputra before turning almost due south as it enters Bangladesh. Until the late 18th century the curve of the river continued, producing a southeasterly course to the east of the Madhupur Forest Tract and into the southern end of the Sylhet Basin where it joined the Upper Meghna River. The combined flow entered the Bay of Bengal along the present course of the Lower Meghna estuary.

This drainage pattern is clear on Rennell's map of around 1770, but by the time of the Wilcox map of the 1830s the situation had changed drastically. In the intervening period the Brahmaputra shifted 60 km and adopted a new course west of the Madhupur Forest Tract. The river this shift created is called the Jamuna, the name Brahmaputra being retained for the former course. As a result of this shift, the Brahmaputra-Jamuna formed a new confluence with the Ganges, creating a very large river called the Padma. For a few years the Padma followed the old course of the Ganges along the Arial Khan, but soon the great increase in the volume of flow led to a major avulsive shift when the Padma broke through a neck of more resistant sediments (Chandina Alluvium) north of Shariatpur, to meet the Meghna near Chandpur.

Following the breakthrough of the Padma, the Lower Meghna enlarged to accept the combined drainage of the Ganges, Jamuna, and Meghna. The river is still adjusting to the resulting change in flow orientation since the Padma flow is turned through almost 90 degrees as it exits the gap in the Chandina Alluvium. The big bend so produced is still in evidence today. Its tendency to migrate eastward through erosion of the outer (east) bank north of Chandpur is a consequence of the great change in momentum associated with turning many thousands of cumecs of water flowing at high speed around a comparatively tight corner. The Arial Khan remains an important regional river and spill channel of the Padma.

The Padma today is a very large watercourse. Its total catchment area is that of the Brahmaputra and Ganges combined—about 1,679,000 km^2 (Rogers *et al.*, 1989). The dominant bankfull discharge is about 70,000 cumecs, making this the fourth largest river in the world (FAP 4, 1993). The annual hydrograph of the river is driven by a combination of snowmelt from the Himalayas and monsoon rainfall. In most years the flood peak on the Jamuna occurs in July, and that on the Ganges in late August or early September, resulting in a prolonged flood peak on the Padma.

The basins of the Ganges and Brahmaputra are bounded by the highest and most tectonically active mountain range in the world. These young alpine mountains are naturally subject to severe erosion. Also, in the case of the Ganges, land use changes in the foothills of the Himalayas have increased slope wash and erosion, adding to sediment yields in Ganges tributaries. This, however, has not been demonstrated to add significantly to the sediment load several hundred kilometers downstream in Bangladesh. The annual sediment load of the Brahmaputra is around 500 million tons per year (FAP 1, 1992); this makes the Brahmaputra third among the world's rivers in terms of sediment load. The load of the Ganges is around 450 million tons per year (FAP 4, 1993). The Padma receives both these sediment loads and therefore transports around one billion metric tons of sediment annually.

The large and variable flow, coupled with a high sediment load, results in a complex and dynamic wandering river. The Padma is in constant transition between a single-thread meandering pattern and multi-channel braiding. While elements of both patterns are always discernible, at different times and places one pattern becomes dominant. Wandering rivers are characterized by continuous lateral movement due to incremental and avulsive channel shifting associated with the development and cut-off of meander loops, the growth of chars, and widespread bank erosion. Rapid lateral shifting generally is contained within a geomorphologically active river corridor wide enough to contain both the meander amplitude of the single-thread phase and the braid belt of the multi-thread phase. Bank erosion attacking the floodplain occurs in both phases wherever either meander loops or braid-bar embayments deflect the river against the edge of the active corridor.

2.3 Methodology

2.3.1 Satellite Image Selection

A pair of dry season satellite images from 1984 and 1993 were selected to study changes in river dynamics, charland geometry, and vegetation distribution. The river banks, as well as the chars, could be mapped with a precision and consistency that enabled local characterization in greater detail than could be compiled from available map sources. The images selected for the study were obtained from satellite image archives in the United States and Thailand (Table 2.1).

Table 2.1 Satellite Imagery Used for the Padma Char Study

Date	Path/Row	Sensor
March 19, 1984	137/44	MSS
January 15, 1993	137/44	TM

Data from two Landsat satellite sensors were used: the Multi-Spectral Scanner (MSS) derived data for 1984 and the Thematic Mapper (TM) for 1993. The 1984 data were a subset of an MSS image mosaic of Bangladesh that had been generalized from 80 m to 100 m ground resolution.[1] The TM data were used for 1993 because that sensor provides high-resolution images (30 m) and is more suitable for analyzing current conditions.

2.3.2 Image Preprocessing and Rectification

The images listed in Table 2.1 were acquired on nine-track computer tape, read into FAP 19's ERDAS image processing system, rectified to geographic coordinates, and fixed to the Bangladesh Transverse Mercator (BTM) projection using control points selected from 1989 SPOT image prints. The prints, at 1:50,000 scale, were supplied to FAP 19 by the FPCO. Each satellite scene was then clipped to a precise rectangular region covering the Ganges-Jamuna confluence and the Padma River up to but not including the Meghna confluence, an area approximately 55 km north-south by 75 km east-west (Figures 2.1 and 2.2).

The Padma-Meghna confluence was not included since the char and erosion dynamics of this area were of most relevance to the Lower Meghna and are covered in the Meghna Inventory report (FAP 16/19, 1993).

2.3.3 Satellite Image Classification

To create precise, comparable maps of river channel features, each digital satellite image grid cell, or pixel, was classified according to its image brightness and color. This multispectral image classification methodology evolved through a series of tests using standard classification techniques described in Richards (1986). Generally speaking, similar surfaces or types of ground cover produce a distinct range of spectral responses known as a signature. Digital algorithms were used to recognize and statistically define these spectral patterns in the image data. Next, the pixels were sorted into one of the proposed classes (signatures) through the use of a mathematically- based decision rule (maximum likelihood). Finally, the land cover features to which each proposed class corresponded were identified, and analogous categories were combined. The final product was an image composed of four classes: water, sand, cultivated/bare soil, and natural vegetation. This method and classification had already been used for the Jamuna charlands.

Table 2.2 Comparison of 1993 Image Classification with Verified Land Type

	Area Verified in the Field		Classified Correctly		Classified Incorrectly	
Land Type	Area (ha)	%	Area (ha)	%	Area (ha)	%
Water	61	25	60	98	1	2
Sand	53	21	48	90	5	10
Cultivated	103	41	97	94	6	6
Vegetated	33	13	32	97	1	3
Total	250	100	238	95	13	5

Source: FAP 19 ground truthing

2.3.4 Accuracy Assessment of Image Classification

The accuracy of the 1993 digital image classification was checked in the field in May 1993. Waterways, land cover, and agronomic practices were observed and compared with spectral signatures on color prints of the original satellite image.

The evaluation compared actual ground conditions with those interpreted from the image ("ground truthing") at 28 sites on the river banks and chars of the Padma. For each site a polygon was depicted on the print of the satellite image. The polygons were selected for image areas with relatively uniform spectral characteristics and for ground areas of about 10 to 20 ha. After locations were verified using a hand-held global positioning system (GPS) receiver, land cover and conditions were noted, and local people were questioned about conditions at the time the image was taken.

Field information was used to assign a class to the polygon for each field ground truth site. There were a total of six classes corresponding to types of cultivated land (cropped and emerging crop or fallow), natural vegetation (homestead and catkin grass), and one class each for sand and water. Using a computer cross-referencing program, coincident pixels, each representing a ground area of 0.09 ha on the 1993 classified Landsat image, were compared with the polygon classes for the ground sample sites.

Accuracy was determined by the percentage of ground truth sites correctly classified. Table 2.2 summarizes the results of this exercise and shows that overall classification accuracy was 95 percent.

All classes were at least 90 percent accurate, and water, at 98 percent accuracy, registered the best results. Slightly lower accuracy is shown for sandy areas, which can be confused with cultivated land (fallow or emerging crops). Some errors also may be attributed to the time lapse of four months between the time the image was taken and the formal ground truthing observations, inaccurate responses from interviews, or variability in sample areas. Cultivated and natural vegetation classes were subsequently combined because they have similar meanings in the context of this study and were not clearly distinguishable. The simple three-category classification used in the remainder of the study had an even higher accuracy.

Since the satellite image processing was initiated in 1993, it was impossible to perform an accuracy

1984 DRY SEASON SATELLITE IMAGE

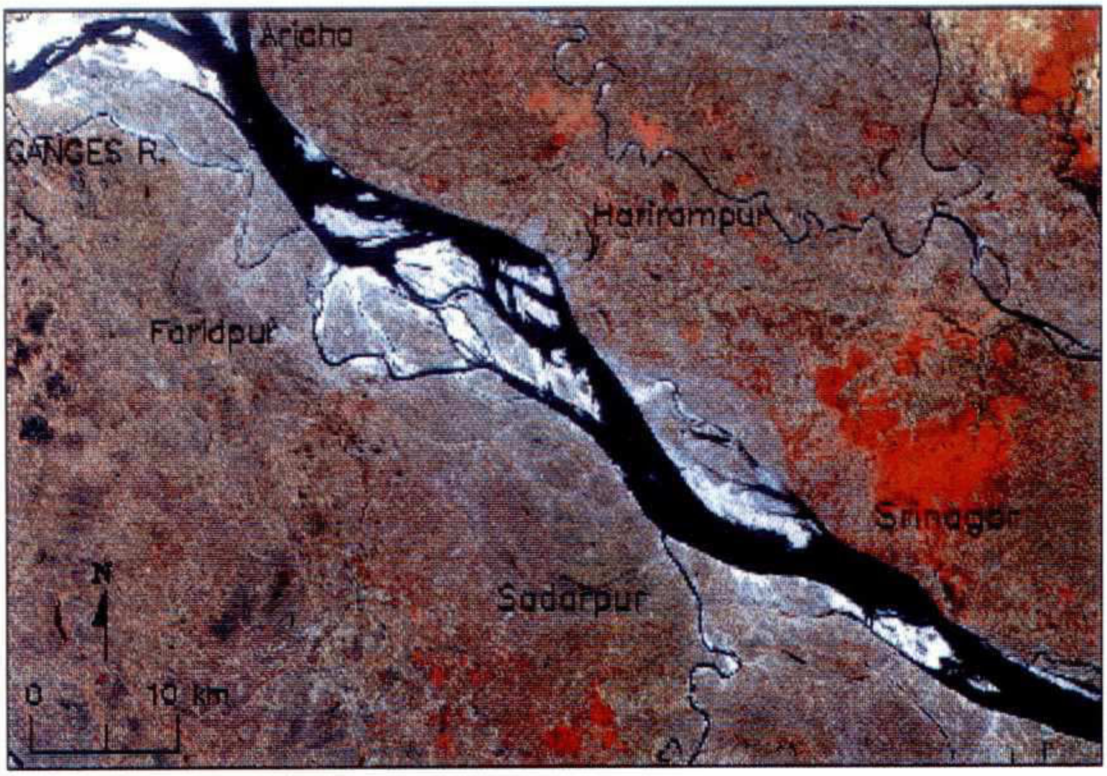


Figure 2.1

Source: ISPAN, Landsat TM image.

1993 DRY SEASON SATELLITE IMAGE

Figure 2.2

Source: ISPAN, Landsat MSS image.

assessment of the 1984 image. It is expected, though, that assessment of the 1984 image would yield similar accuracies since it was also recorded during the dry season and was subjected to the same image classification procedures.

Finally, the classified 1984 (MSS) and 1993 (TM) images were resampled to a common pixel size of 80 by 80 m to provide a consistent foundation for analysis. The classified 1993 image formed the basis of the analysis in Chapters 2 and 3 and is shown in Figure 3.2.

2.3.5 Bankline Delineation

The criteria for bankline interpretation of the satellite images were determined during the Jamuna study after discussions with various experts, including river morphologists and engineers from FAPs 1, 21/22, and 25. Images were displayed at full resolution on large-format, high-resolution computer monitors, and the river bankline and char boundaries were digitized and saved as BTM map coordinates. Generally speaking, the banklines encompass main channels, island chars, and sandbars. The distinction between attached and island chars is unclear in places, making bankline delineation a highly subjective matter. After review and finalization, maps of both years' river channel area were created. The advantage of these maps was that bankline and char features could be distinguished and quantified, which allowed temporal comparison of spatial patterns. Detailed analysis of these changes over the period is described below.

2.4 Riverbank Erosion and Accretion

2.4.1 Context

The wandering of the Padma creates rapid bank erosion. Banks inside the geomorphologically active corridor are of recently deposited sands and silts that are highly erodible. Floodplain materials outside the active corridor are older and more consolidated, so banks are more resistant at the edge of the corridor. Consequently, rates of floodplain erosion and shifting of the corridor tend to be lower than those of channel shifting and bank erosion actually within the active corridor. This fact is not always recognized and can lead to misunderstandings concerning the erosion risk along the Padma. The assessment of historic trends in the morphology of the Padma in this section is based on work undertaken by FAP 4 (1993), which attempted to identify the active geomorphic corridor of the river in order to assess the erosion threat to embankments and other structures.

FAP 19 attempted to quantify the actual rates of bank erosion along the Padma River based on satellite images. Products of the analysis include bank erosion rates, estimates of the loss of mainland area to erosion, and estimates of the population affected (Chapter 4). Some indications of future erosion patterns are given, but analysis of a series of satellite images would be needed to improve their reliability.

2.4.2 Channel Morphology

The Padma River was created 150 to 200 years ago when the river systems of present-day Bangladesh underwent a series of major upheavals (Section 2.2), and significant changes have taken place since its creation. Geomorphologically the river is still young and has not had sufficient time to develop a channel adjusted to accommodate its flow and sediment load. The river channel and active corridor may still be evolving, the three-dimensional geometry of the channel is undergoing a process of unsteady adjustment. Eventually it should achieve a form that is in dynamic equilibrium with the flow and sediment regimes. If this is the case, the characteristics of past and present channel evolution should give a reasonable indication of future trends, at least over short and medium time scales.

The three-dimensional geometry of the channel is defined by its long-profile, cross-section, and planform pattern. The FAP 4 (1993) analysis of long-profile and specific gauge records for the Padma at Baruria and Mawa found no statistically significant trends in water levels for specific discharges over the period of record since 1965, nor did there appear to be any trend in bed levels. While there are short-term changes, these are probably associated with the dynamics of bars and scour pools in the wandering river and not indicative of any sustained trend. In contrast, the positions of banklines and planform configuration of the river have changed radically over the past 200 years and continue to change today.

Analyses of historical maps (FAP 4) and satellite images (FAP 19) are described in detail in the following sections. These show that the river planform has varied between mainly braided, with a remarkably straight alignment, and meandering, with very large, sweeping bends that swing from one side of the active corridor to the other and tend to increase the width of that corridor through simultaneous erosion of both the north and south banks.

2.4.3 Channel Migration

Historic Figure II (following page) highlights some of the changes in channel morphology by comparing the lower Ganges and Padma banklines digitized from historic maps by FAP 4 with the 1993 banklines (FAP 19). Bankline and centerline movement, and channel widths have also been calculated at 5 km intervals along the Padma using a southwest-northeast oriented grid superimposed on the 1984 and 1993 image-derived banklines.

In 1779, the Padma was simply the downstream continuation of the Ganges below Goalando and Aricha (upper map in the figure, in red). There were a pair of bends close to the present confluence with the Jamuna, the loop of the second bend being just upstream of Faridpur. By 1860 (green in the figure) the avulsion of the Jamuna-Brahmaputra had completely altered the flow and sediment regimes, leading to massive increases in water discharge and sediment input and creating the Padma. The river, in response, enlarged its capacity through rapid widening and increased its braiding tendency. By 1860 a very wide channel with massive island chars and point bars is evident, the most prominent loop being through a right bank distributary in the vicinity of the present day Arial Khan River.

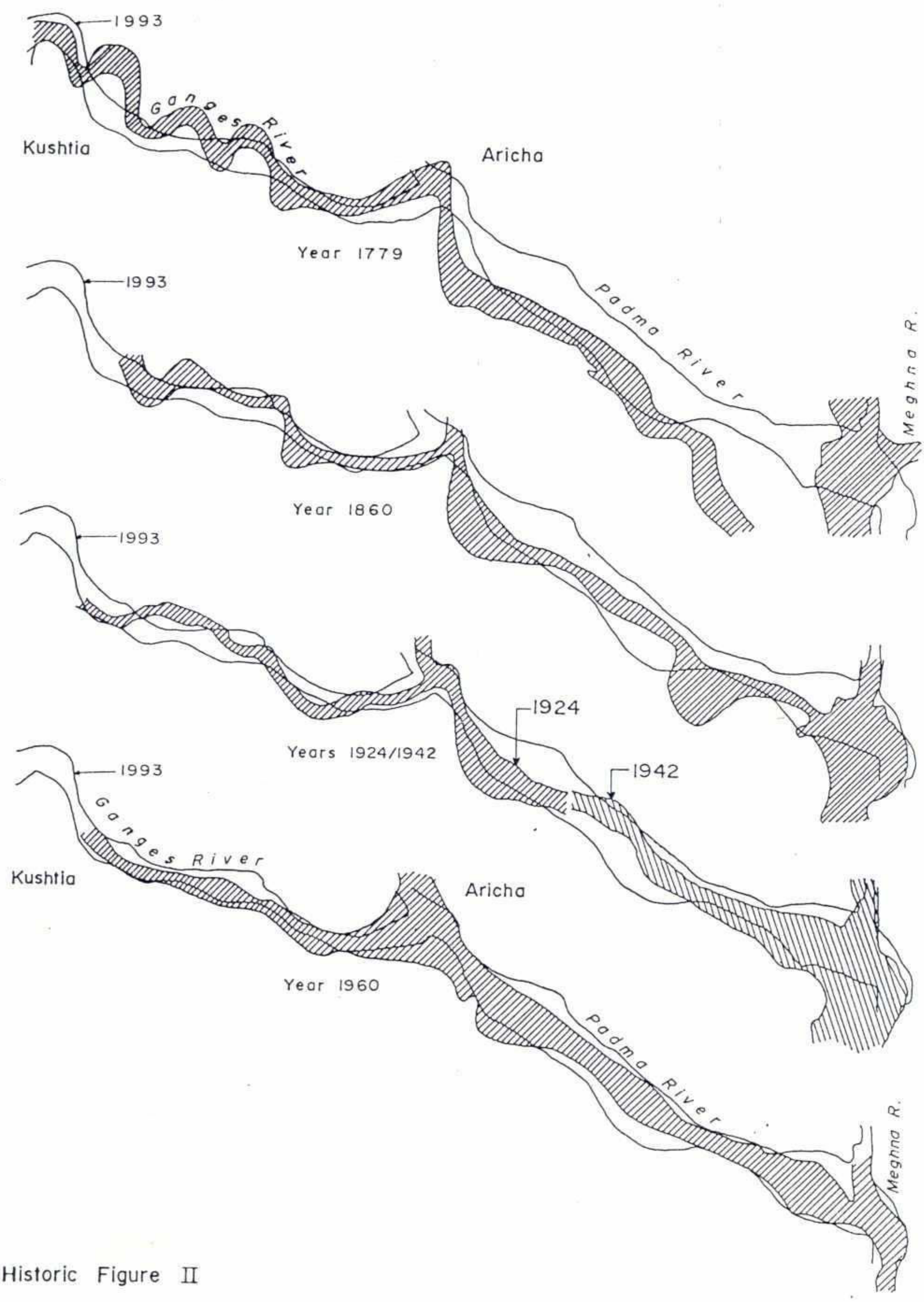
Braiding, which tended to straighten the channel, predominated in the next period. Maps of 1924 and 1942 (blue in the figure) show a heavily braided river and a reduced sinuosity. The increase in width compared to the 1779 channel is mostly due to left (north) bank erosion that resulted in a northward shift in the channel centerline. This braided pattern and straight alignment is also evident in the 1960 map (yellow in the figure), by which date the river had widened still further.

By 1973 the planform had developed a series of large bends, dominated by major loops in the right bank at Faridpur, at the mouth of the Arial Khan, and around Shariatpur. These loops cut embayments into the edge of the active corridor on both sides, leading to widening of the active corridor and loss of floodplain land north and south of the river.

As Figure 2.3 shows, by 1984 the loops had been abandoned by chute cut-offs, and the course of the river had become remarkably straight, but with pronounced island clusters and intervening nodes. The width of the active corridor south of Srinagar (near Mawa) is constricted, and more resistant sediments are found further downstream, but this may by chance be a stable node in the braided pattern. Considerable time may therefore have to elapse before the active corridor has widened sufficiently to entirely accommodate this vast wandering river. The embayments in the right bank cut during the previous meandering phase remain as slough channels, which are still clearly visible in the 1984 image.

In Figure 2.4, showing the Padma in 1993, the river has re-established a predominantly meandering course, although significant divided flow reaches are still apparent. Elements of meandering and braiding are clearly present in the form of sweeping bends with distinct cross-overs and island clusters with nodal reaches between them. This is characteristic of a wandering river in transition between meandering and braiding.

HISTORIC BANKLINE POSITION OF THE GANGES — PADMA RIVERS



Historic Figure II

Source : FAP 4 and FAP 19

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BANKLINE MOVEMENT: 1984 IMAGE

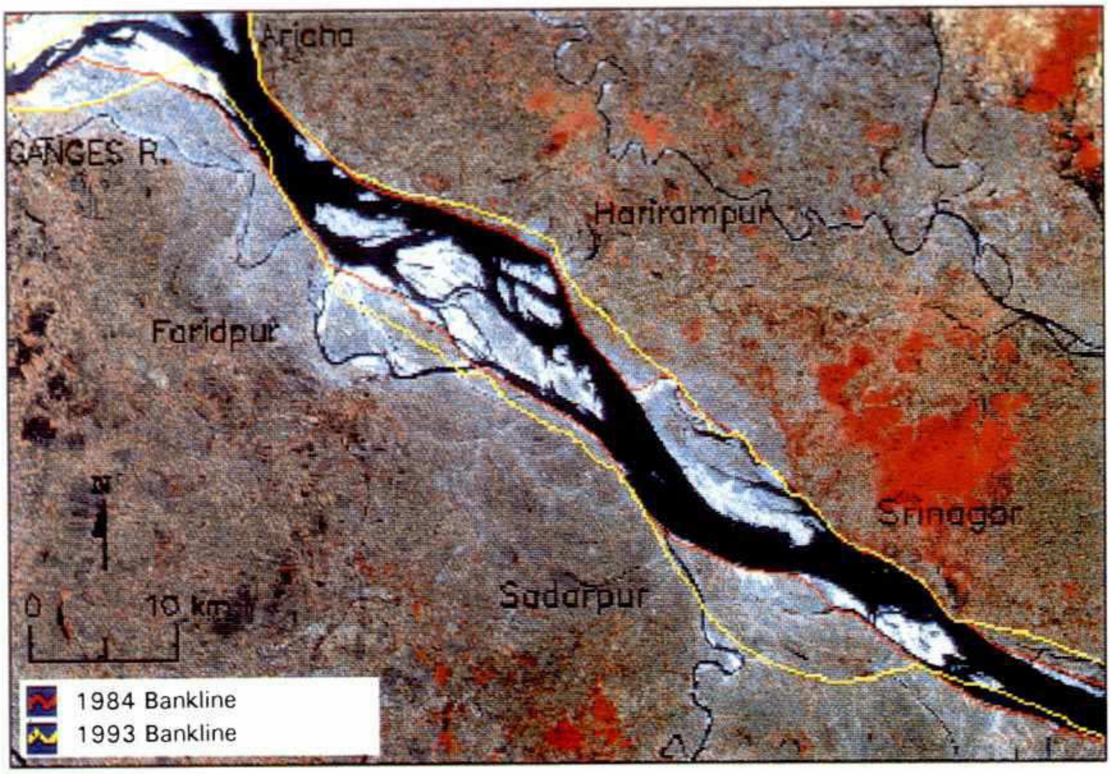


Figure 2.3

Source: ISPAN, Landsat images.

BANKLINE MOVEMENT: 1993 IMAGE

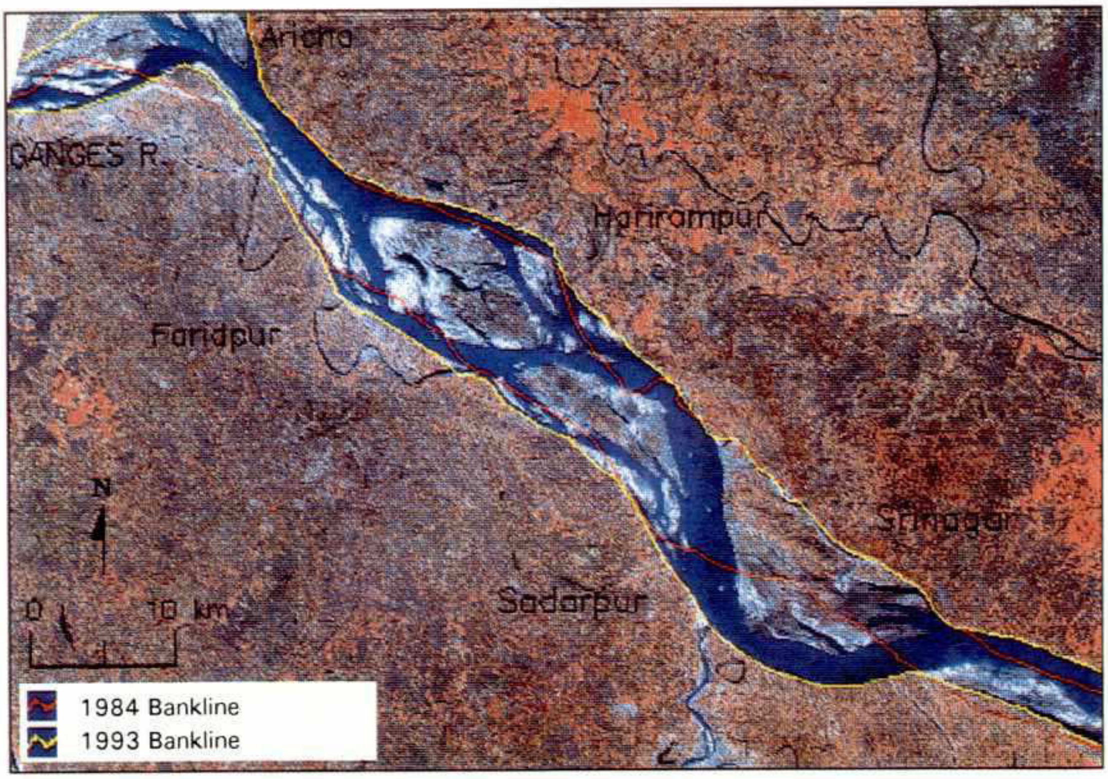


Figure 2.4

Source: ISPAN, Landsat images.

Image analysis of the dry season river channel revealed that between 1984 and 1993 there was little movement of the channel centerline throughout the upper and middle reaches, where average movements were 116 m south and 162 m north, respectively (Figure 2.5). By comparison, the lower reach shifted dramatically as a result of increasing sinuosity. East of Sadarpur the centerline meandered as much as 2 km south, whereas a shift of 1.1 km north was recorded for the area approaching the Meghna confluence. These shifts translate to annual movements of 221 m southward and 125 m northward.

Despite these recent developments, the generally southeast orientation of the channel axis has been maintained for more than 150 years. This is probably at least partly due to the restraining effects of outcrops of erosion-resistant Chandina Alluvium on both banks of the river just downstream of Shariatpur. The width of the active morphological corridor is insufficient to contain either the bendway amplitude of the river in its predominantly meandering configuration, or the braid belt/island cluster width of its braiding phase. Hence, continued erosion of the floodplain may be expected in the future.

Summarizing the 1984-1993 period, the upper and middle reach channel positions were more or less stable, while the Padma's lower reach developed a pronounced meander. The lower Padma has shifted southward in the vicinity of Sadarpur, and northward as it nears the Meghna confluence.

2.4.4 Channel Widening and Bank Erosion

Banklines were manually digitized from the satellite images (see Figures 2.3 and 2.4) and analyzed to determine bank erosion rates between 1984 and 1993. Bankline shifts at river cross-sections (Figure 2.6) were assigned positive values for accretion and negative values for erosion.

Trends in channel width since 1984 follow the same general patterns as those exhibited by the centerline analysis (Table 2.3). The left and right banks in the middle reach shifted up to 1 km or more to the north and south, respectively, resulting in widening but no centerline movement. In the lower reach, the bankline moved approximately 5.5 km to the south in the area just east of Sadarpur, and up to 1.5 km north east of Srinagar.

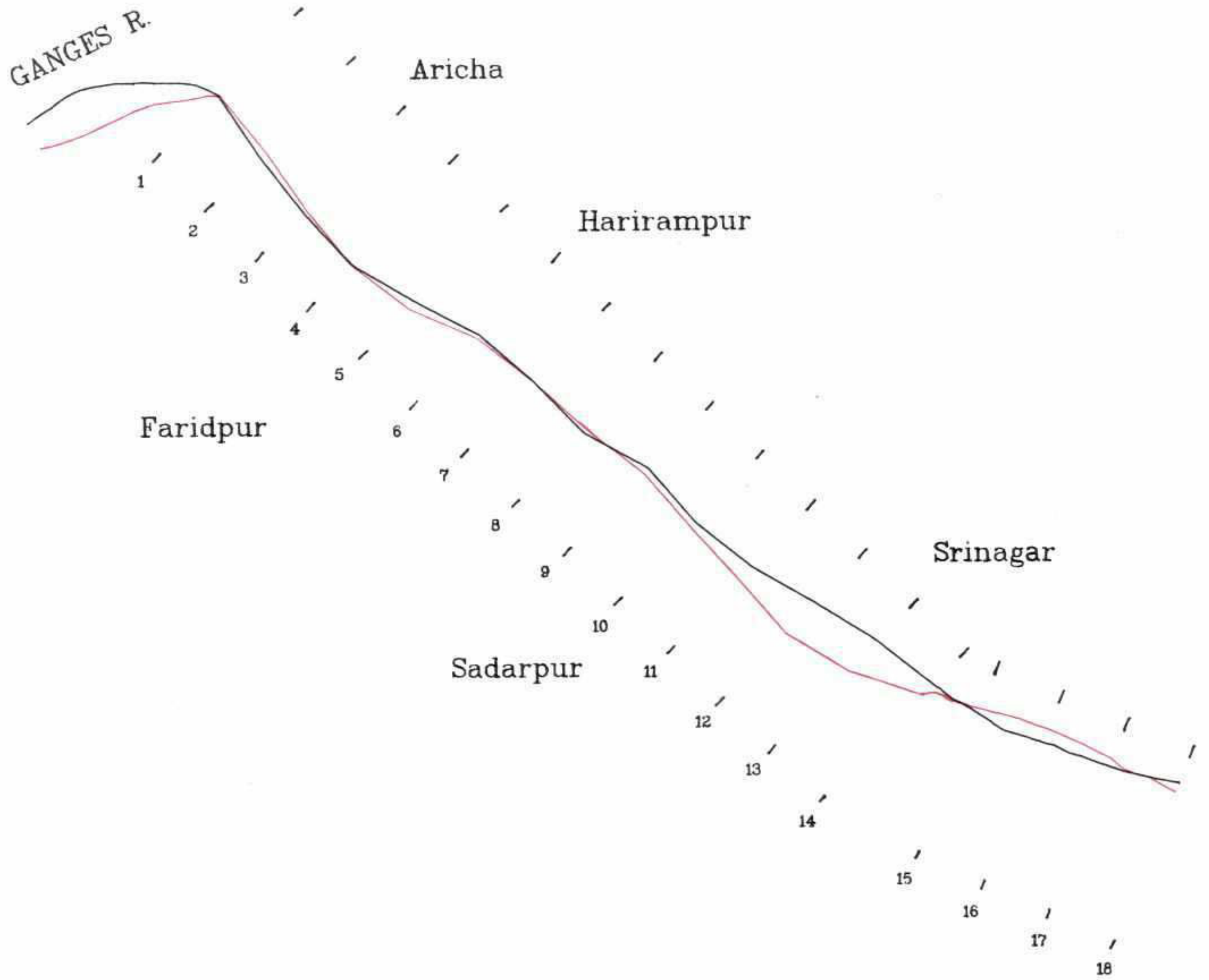
Figure 2.6 shows that channel width has decreased slightly in the upper reach (cross-sections 1-4), and within the middle and lower reaches (cross-sections 5-10 and 11-18) river width has increased at nearly all cross-sections. The average 1984 width of the upper reach was 5.1 km, in the middle reach about 7.3 km, and in the lower reach

Table 2.3 Average Width (km) of the Padma 1984-1993

Reach		Year	Average	Maximum	Minimum
Upper		1984	5.10	8.21	3.63
		1993	4.86	7.74	2.71
	Change		-0.24	-0.47	-0.92
Middle		1984	7.32	8.48	5.34
		1993	8.85	10.66	7.41
	Change		+1.53	+2.18	+2.07
Lower		1984	4.76	7.39	3.73
		1993	6.95	10.36	4.27
	Change		+2.19	+2.97	+0.54

Sources: 1984 and 1993, Landsat images

Center Line Migration (1984–1993)



Migration From 1984 Center Line(m)

Cross-section (5Km Reaches)	1993
1	1
2	339
3	155
4	-30
5	-469
6	-176
7	7
8	242
9	-293
10	-281
11	-825
12	-1986
13	-1939
14	-823
15	463
16	1122
17	714
18	-416
Mean	-233

1984

1993

Figure 2.5

ISPAN

FAP19 Geographic Information System

Table 2.4 Bankline Erosion/Accretion by Reach 1984-1993*

Reach	Eroded Area (Ha)	Accreted Area (Ha)
Upper	1798	1163
Middle	6043	134
Lower	8365	797
Total	16,206	2,094

Source: FAP 19 Satellite image analysis
*Summed on a mauza basis resulting in small differences from the estimated increase in within-bankline area.

about 4.8 km. By 1993 the average width of the upper reach was almost the same, while the middle and lower reaches had widened by 1.5 km and 2 km, respectively (Figure 2.6 and Table 2.3).

Width increases were most dramatic between Harirampur and Srinagar (cross-sections 5-14). In the middle reach, widening resulted from equal erosion rates (85 m per year) on the two banks. In the lower reach, sections 11-14 exhibited both the greatest channel widening and highest level of bank erosion. Widening occurred as a result of the Padma's increased meandering, causing an attack on the right bank. Right bank erosion in this section averaged 437 m per year, with a maximum right bank shift of 5.6 km.

Almost eight times more land was eroded along the banklines than was accreted between 1984 and 1993 (Table 2.4). In terms of area lost, the middle and lower reaches were comparable since in the middle reach there was erosion of both banks, although the erosion rate was less.

Table 2.5 summarizes net erosion and accretion rates. The highest nine-year erosion rate for a 5 km sub-reach was 623 m per year on the right bank east of Sadarpur. The mean erosion rate was 38 m per year for the left bank and 121 m per year for the right bank. Erosion rates greater than 200 m per year were exceptional, occurring at less than 14 percent of the cross-sections, and were only typical in the lower reach right bank.

Table 2.5 Mean Bankline Erosion/Accretion Rates; 1984-1993*

Bank	Change	Upper	Middle	Lower	Total
Right	Shift 84-93 (m)	262	-997	-1834	-1090
	Rate (m/yr)	29	-111	-204	-121
Left	Shift 84-93 (m)	-21	-535	-348	-338
	Rate (m/yr)	-2	-59	-39	-38

Source: FAP 19 satellite image analysis
*Negative = net erosion; positive = net accretion

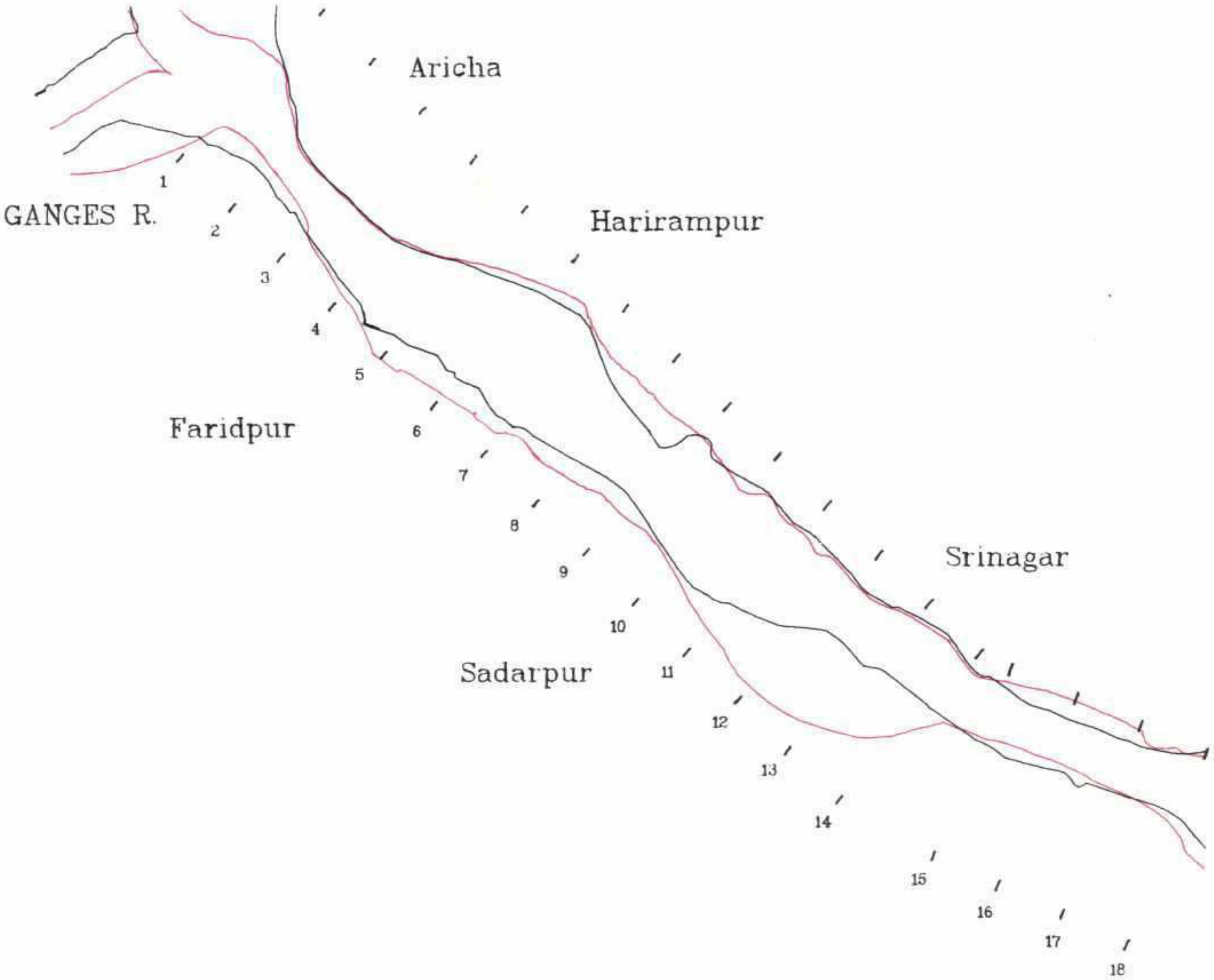
2.4.5 Overview of Channel Changes

Figure 2.7 shows the successive low flow channels of 1984 and 1993, which reveals some of the channel planform changes underlying the bankline erosion discussed above. This map was prepared by overlaying the river channels from the classified 1984 and 1993 satellite images. In a qualitative sense, this map illustrates the migration of the dominant channel more effectively than the bankline delineation. The southward shift in the channel east of Sadarpur appears even more dramatic from this perspective. This is because within-bank island chars are sometimes morphologically similar to mainland. The island char on the left bank adjacent to Srinagar exemplifies such a situation (Figure 2.4). Thus, the calculated centerline in this river section would move even farther south if this char were not considered part of the channel.[2]

By concentrating on bank changes in the main channel the complex changes in the river can be simplified. Figure 2.8 shows the net change in river banklines between 1984 and 1993, and the types of land lost and gained. It demonstrates overall widening of the river through consistent

Bankline Positions and Width

(1984–1993)



Channel Width (m)

Cross-section (5 Km Reaches)	1984	1993	Change	Rate m/year
1	8210	7735	-475	-53
2	3628	2714	-914	-102
3	3793	3484	-309	-34
4	4761	5498	737	82
5	7179	9388	2208	245
6	8425	10655	2230	248
7	8477	9383	906	101
8	5335	8432	3097	344
9	6609	7828	1220	135
10	7880	7413	-467	-52
11	7392	9589	2197	244
12	4797	10325	5529	614
13	4915	10361	5447	605
14	4148	6468	2319	258
15	4237	4272	35	4
16	3760	4497	737	82
17	3728	4575	847	94
18	5123	5473	351	39
Mean	5689	7116	1427	159

— 1984

— 1993

Figure 2.6

ISPAN

FAP19 Geographic Information System

erosion along much of the left and right banks. The right banks of the Padma near both the Jamuna-Ganges and Meghna confluences, however, are the only areas where a significant amount of accretion took place. Table 2.4 shows that the area of net accretion was only 13 percent of the area of mainland lost to erosion.

Figure 2.8 also indicates the complexity of changes that have taken place during the nine years. For example, some locations have changed from mainland to char. This may be because land broke away from the mainland or land eroded and later accreted. Additional images acquired within the nine-year period 1984-1993 would reveal the sequence of changes in such areas.

Analysis of a series of satellite images at intervals of three to four years has not yet been carried out for the Padma, unlike the Jamuna. Comparable analysis for the Padma is needed to understand the complex changes that have taken place. Only one rate of change could be calculated for the years 1984-1993. This effectively generalizes an intangible amount of physical change in river morphology and rates of change for the period. Since those years included the floods of 1987 and 1988, bank erosion rates in those years, on the basis of the Jamuna study, would have been much higher.

2.5 Within-Bank Dynamics

2.5.1 Summary of Char Morphology

The geomorphology of wandering rivers in transition between meandering and braiding is poorly understood. The mechanics of meandering can be reasonably well explained and channel changes are somewhat predictable. In the case of braided rivers, the situation is less clear, although the basic processes of braid bar formation, flow detection, and bank erosion have been described.

In a wandering river, elements of both patterns and associated flow processes are present at all times and at all locations to a greater or lesser degree. At any given time, though, sections may be dominated by either braiding or meandering tendencies, so that adjacent river reaches may display contrasting channel planform characteristics. Similarly, at a given location, the planform will vary through time from predominantly meandering to braided and back again. These changes may not be evolutionary or have any particular cause, they simply may be cyclical and inherent to a wandering river pattern that is in quasi-stable equilibrium.

The interpretation and prediction of detailed channel planform changes within the outer banklines defining the active geomorphic corridor is particularly difficult in wandering rivers such as the Padma. Despite this, some general characterizations can be made.

The main channel of the Padma displays elements of meandering and braiding, but its recent planform has been unusually straight for an alluvial river. The channel, oriented almost directly southeast from the confluence of the Ganges and Jamuna at Goalando to the confluence with the Meghna (where the main flow bends southward), has not always been so straight. As recently as 1973 there were still major southern loops in the areas of Faridpur and the off-take of the Arial Khan. The north bank also has scars left by large embankments. The general spacing of the scars and past embayments is consistent with their being formed by bank erosion in meander loops and around island chars (medial braid bars). Historically, island chars in the braided channel have been about 15 km long, and FAP 9B (1990) found that chars moved downstream in the Padma with a periodicity of 15 years.

Assessment of the 1993 dry season Landsat image shows that in January 1993 the Padma study area had a total of 13 island chars longer than 3.5 km (large). An additional 18 island chars were between 0.35-3.5 km in length (small); this includes both chars that were pure sand (and are categorized as sand in the following sections) and ones that were vegetated. Very small islands (under 350 m long) have not been counted, but appeared invariably to consist of sand.

LOW FLOW CHANNEL MIGRATION

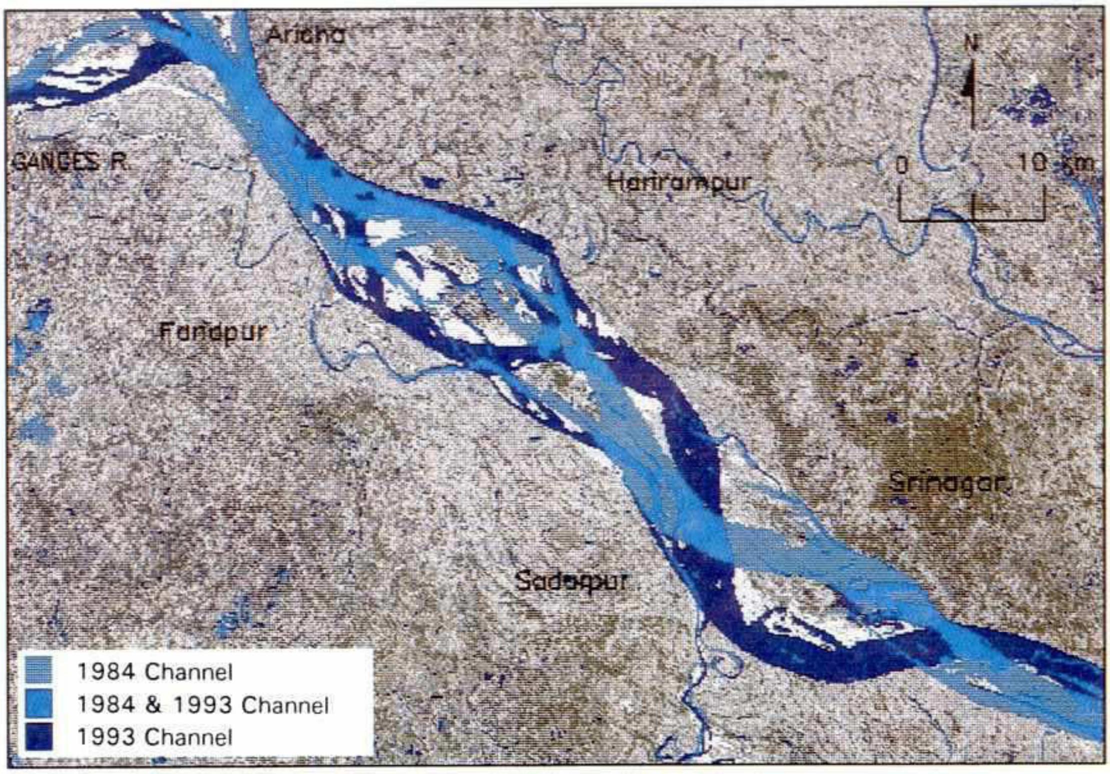


Figure 2.7

Source: ISPAN, Landsat images of 1984 and 1993.

RIVER BANK EROSION AND ACCRETION 1984-93

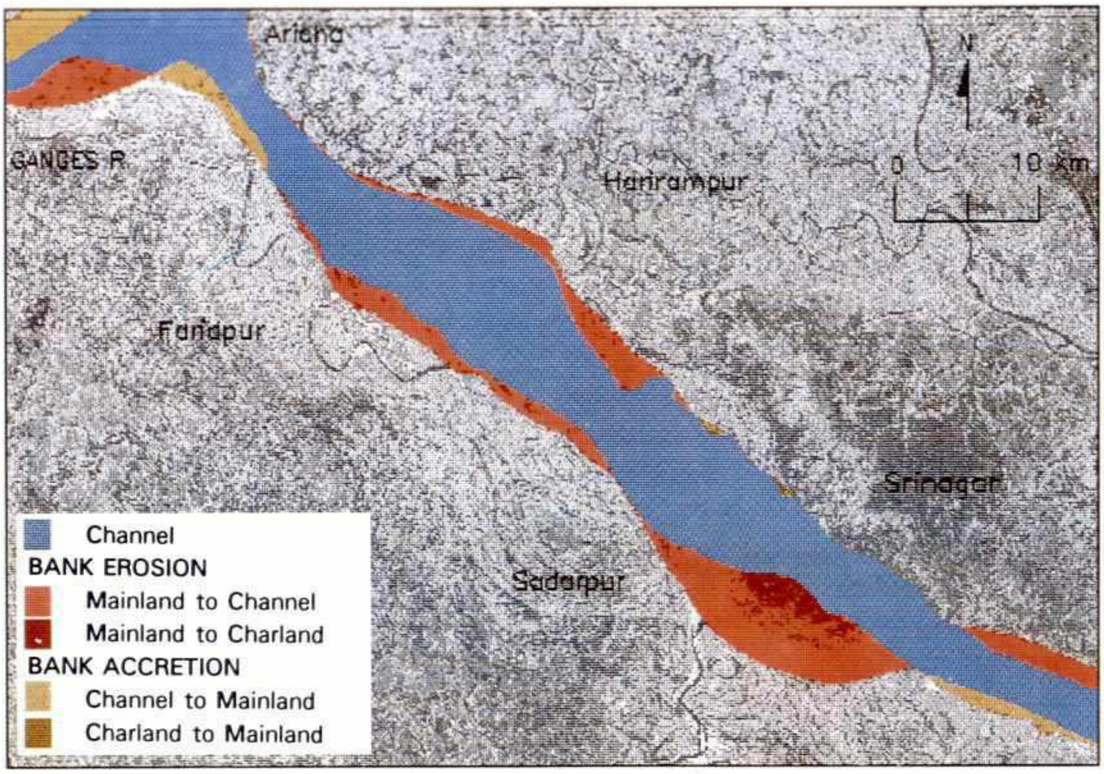


Figure 2.8

Source: ISPAN, Landsat images of 1984 and 1993.

The number of sub-channels in the Padma is related to the width of the primary channel. At the Mawa nodal point, where the width is only 3.5 km, there is just one channel. The river is 12-15 km wide in reaches that have two anabranches. The Padma is less braided and much narrower than would be expected given its flow and sediment regime. FAP 9B (1990) concluded that it has the stream power to braid more intensively and therefore to widen its channel markedly. Increased braiding could be triggered by a relatively subtle change in the river regime, or by the river breaking through a hard point and into more erodible land at some critical locations. This would lead the river to cross a geomorphic threshold in planform control from wandering to braided. This potential for rapid channel changes and widening should be borne in mind when making decisions about locating embankments and other structures near the present banklines.

The most recent trend in channel planform development seems to be toward pronounced meandering rather than braiding. This would be consistent with past cycles of planform change. Stronger meandering has implications for charlands, distributary off-takes, and channel management. In a meandering channel, charland primarily tends to be attached rather than in islands, which has advantages for charland dwellers.

Progressive meander loop development and abandonment has particularly strong effects on distributaries such as the Old Kumar and Arial Khan. In former times, when a meandering pattern predominated, loops that occupied embayments at Faridpur and the Arial Khan ensured a plentiful supply of water from the main river at all times. With channel straightening since the 1970s, the Old Kumar was abandoned except as a high season over-spill channel. The Arial Khan, meanwhile, had sufficient low flow resistance that it was able to draw water across intervening bars and remain a perennial distributary. If meandering again becomes dominant, these off-takes might be reactivated. In view of the critical shortage of fresh water in the southwest and south-central regions, this should be monitored closely.

Since the morphology of meandering rivers is better understood, the onset of a meandering tendency in the Padma could offer the opportunity for better predictions of short- and medium-term bankline changes. If such predictions can be made, then sites for embankments and regulators may be selected with more confidence, and channel training that combines the use of hard structures and active floodplain management may become a possibility.

In summary, re-establishment of a predominantly meandering pattern to the Padma seems likely over the next 20 years. Bank attack will be concentrated in the outer bank downstream of bends, which may erode the edge of the river corridor.

2.5.2 Image Analysis of Within-Bank Changes

The within-bank area on each of the images was classified as explained in Section 2.3.3. Char[3] areas are distinct from the other predominant landscape components of water, including saturated zones along water edges, and sand, including areas of sparse grass cover. The classifications are in grid-cell format and are the result of digital image processing as described in Section 2.3. The classified image data made mapping and quantification of within-channel changes possible, and resulted in an improved understanding of channel and char evolution.

Changes in water, sand, char, and total area were measured for each of the three reaches. Tables 2.6 and 2.7 summarize this data and indicates that as the river has widened, island chars have increased in size and total area, especially in the lower reach. In 1993, there was almost 2.5 times more vegetated charland within the banklines than there was in 1984. As the river widened, the area of water increased, but only by 14 percent. Widening, therefore, was associated with a major increase in char area, yet this does not compensate for the loss of mainland. Table 2.6 shows there has been a net loss of floodplain mainland of some 14,300 ha in the whole study area, and a gain of about 9,000 ha of vegetated charland within the banklines. Chapter 3 also shows that the quality and carrying capacity of this new land is very different.

Table 2.6 Trends in Within-Bank Area 1984-1993

Area	1984	1993	1993 as % of 1984
Total (ha)	43,397	57,716	133
Water/Sand (ha)	37,148	42,447	114
Char (ha)	6,249	15,269	244
% Water/Sand	86	74	-
% Char	14	26	-

Source: FAP 19 satellite image analysis

In the middle and lower reaches this trend will most likely persist, since the expanded islands and new island clusters deflect the channel flow toward the river's banks, causing rapid erosion[4]. The trend at the confluences is less certain due to the mixing of different sediment and flow regimes, but the two ends of the study area have, over time, remained single-thread channels with little within-bank charland.

Changes in the river channel over short time spans are very complex. Figure 2.9 illustrates the patterns of within-bank erosion and accretion and was produced by overlaying the banklines and classified dry season satellite images. The figure shows changes in char land area and position within the river channel. Green indicates char areas persisting throughout the study period, light red signifies eroded char areas, and tan indicates char areas that were accreted. Areas classified as sand are not considered stable charland and appear as channel in this map. The charlands in this map appear to be incomplete with respect to areal extent due to an overestimation of the sand area in the 1984 classified image. The excess sand area can be attributed to the misclassification of fallow areas and emerging crops as sand. Nevertheless, the map highlights the morphological changes behind the population and resource data that are mapped and discussed in Chapters 3 and 4. Although the char clusters have persisted and grown in area, very little vegetated charland is common to the two images, hence the majority of char inhabitants will have been forced to move as the char system changed.

Table 2.7 Trends in Within-Bank Areas by Reach 1984-1993

Reach	1984	1993	1993 as % of 1984
Upper			
Total (ha)	7,268	8,050	111
Water/Sand (ha)	6,762	6,905	102
Char (ha)	506	1,145	226
% Char	7	14	—
Middle			
Total (ha)	22,491	28,456	127
Water/Sand (ha)	18,392	21,510	117
Char (ha)	4,099	6,946	169
% Char	18	24	—
Lower			
Total (ha)	13,638	21,210	156
Water/Sand (ha)	11,994	14,032	117
Char (ha)	1,644	7,178	437
% Char	12	34	—

Source: FAP 19 satellite image analysis

There are considerable differences between reaches in the composition of within-bank area. The proportion of vegetated charland within the banklines was greatest in the middle and lower reaches: it was 18 percent of the 1984 within-bank area in the middle reach, and 12 percent of the within-bank area in the lower (Table 2.7), but in both cases it rose (to 24 percent and 34 percent, respectively) by 1993. Table 2.7 confirms that by far the greatest increase in char area took place in the lower reach, where a large char emerged in the inner bend of the meander. This has been treated as an island char since it is still separated from the mainland by a substantial channel that could become a main Padma branch if this reach starts to braid.

2.5.3 Char Ages and Erosion

The approximate ages of mainland and charland were determined from key informants as part of the inventory survey. These data, detailed in Chapter 3, were collected on a mauza basis and therefore do not have the spatial accuracy of the image-derived data. Figure 2.10 illustrates the results of this analysis, which corresponds remarkably well with the recent satellite image data and with more general information from historical maps regarding erosion and accretion, and channel migration and widening. The stability and old age of land along the north bank areas in the nodal reaches at either end of the study area is confirmed (in many cases informants could not recall when these areas were settled but referred to several generations or "always settled"). It is also apparent that most attached char mauzas, such as those on the south bank of the upper reach, have been accreted for 20 or more years, while the island chars are mostly reported to have accreted in the past 10 years, which is consistent with the satellite images.

If past persistence implies that chars will continue unbroken existence here, then interventions such as flood shelters and more permanent settlements might be viable in the Padma attached chars but not the island chars. This should be checked by analysis of a longer series of images

These flood- and erosion-prone chars are home to substantial numbers of people. Chapter 3 presents the results of the inventory of people and resources within the banklines and in unprotected mainland along the river, and concludes with information on hazards and floods. Chapter 4 discusses the recent erosion experience reported from these mauzas, and links the bankline analysis of this chapter with population changes in the study area.

NOTES

1. A resolution of 80 meters means that anything smaller than this size cannot be detected; in practice, an object or site may have to be larger to ensure appearance in any one pixel. A pixel is the rectangular area on the earth's surface for which a singe spectral response is given; pixel size nominally is 80 x 80 m for Landsat MSS and 30 x 30 m for Landsat TM.

2. The Landsat images (Figures 2.3 and 2.4) show the complexity of changes on the right bank of the middle reach where there has been bank and char consolidation. The semi-attached char that developed within the banklines on the left bank of the lower reach in the Dohar-Srinagar area is also apparent.

3. Throughout the remainder of this section the term "char" refers to the same landscape component: a surface within the banklines that is either vegetated or under cultivation.

4. Although as meanders develop these chars may become attached to the mainland.

CHARLAND EROSION AND ACCRETION 1984-1993

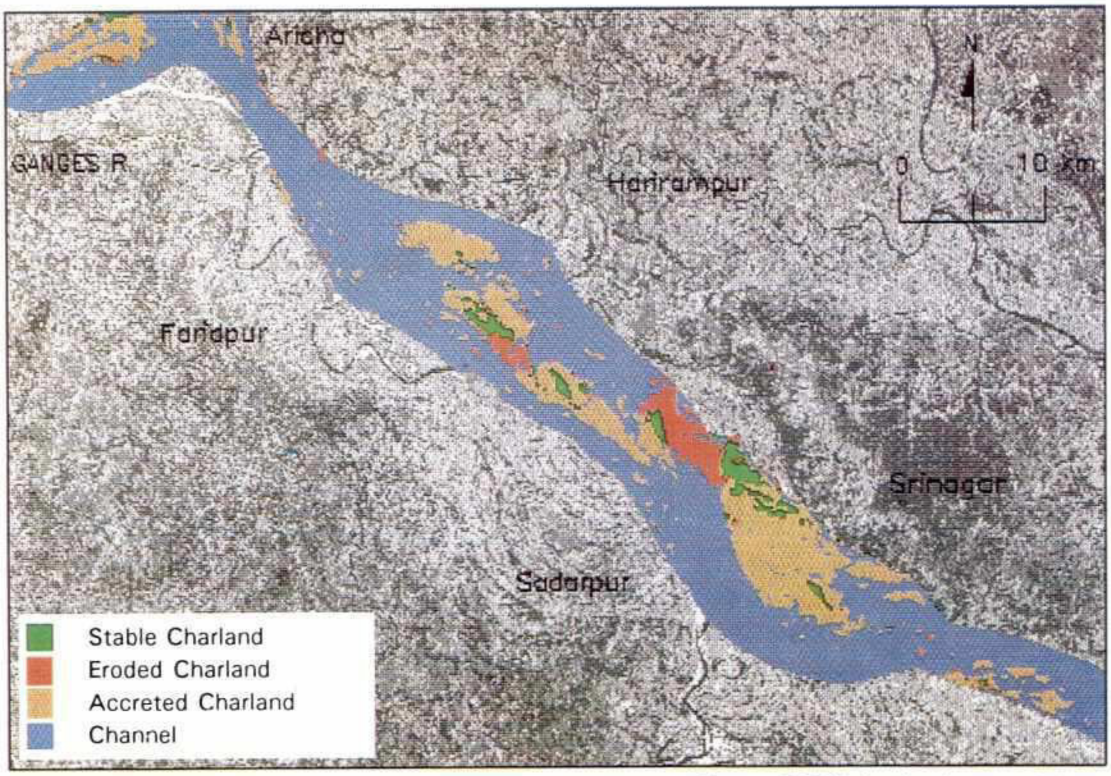


Figure 2.9

Source: ISPAN, Landsat images of 1984 and 1993.

AGE OF LAND

YEARS

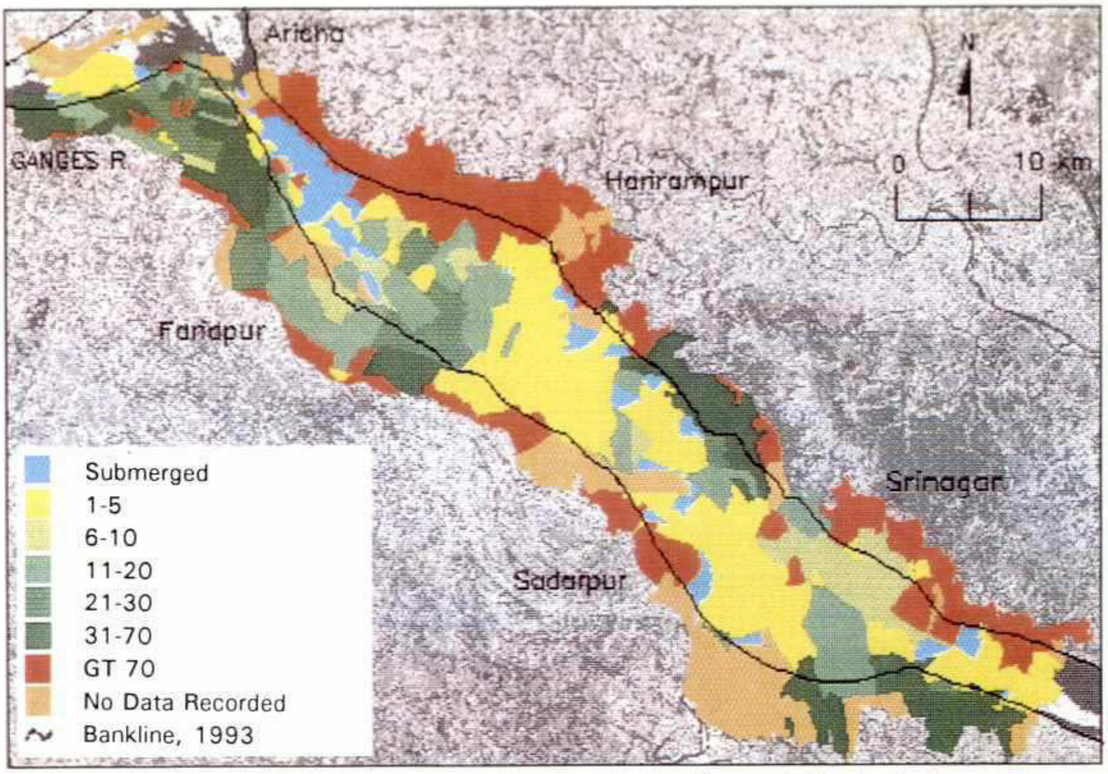


Figure 2.10

Source: ISPAN, Landsat images of 1984 and 1993.

Chapter 3

RESULTS OF THE POPULATION AND RESOURCE INVENTORY

3.1 Introduction

This chapter presents results of the Inventory Survey, which has been linked to the satellite image analysis using a geographic information system (GIS). Land resources in the study area are assessed in Section 3.2.1 based on analysis of the 1993 Landsat image (Figures 3.1 and 3.2). Thereafter, the results of the inventory analyses are mapped and interpreted for the following list of subjects:

- population of the study area in 1981 (census) and 1993 (inventory), changes in population, and availability of cultivable land (Section 3.2.2; Figures 3.3-3.6);
- migration into and out of the study area mauzas in 1992 (Section 3.3; Figures 3.7-3.10);
- infrastructure, primarily education and health facilities (Section 3.4; Figures 3.11-3.14);
- household occupations (Section 3.5.1);
- agriculture (Section 3.5.2; Figures 3.15-3.22);
- livestock relative to land and people (Section 3.5.3; Figures 3.23-3.26);
- boat availability (Section 3.5.4; Figures 3.27 and 3.28);
- land disputes (Section 3.5.5);
- loss of life in the 1988 flood and from other hazards (Section 3.6.1; Figures 3.29 and 3.30);
- flood experience and risk (Sections 3.6.2 and 3.6.4; Figures 3.31-3.36); and
- flood impacts on housing (Section 3.6.3; Figures 3.37-3.44).

In order to interpret the maps and tables correctly, it is necessary to understand some conventions in the maps and some limitations to the methodology of the Inventory Survey.

The inventory-derived maps show mauzas that were uninhabited in 1993 as a separate category (pale blue in the relevant figures). In general, the uninhabited mauzas are either submerged throughout the year or have only sand and natural vegetation above water during the dry season and are submerged in the monsoon. Some uninhabited mauzas in the middle reach of the Padma are cultivated in the dry season by temporary settlers and then abandoned in the monsoon when they are submerged. Submergence was verified by superimposing mauza boundaries on the land use classification map derived from satellite imagery. The survey interviews were conducted in June 1993 some six months after the satellite image was taken but before the monsoon, and these temporary settlements on newly accreted chars were present during the Inventory Survey.

Data for some questions are missing from the survey because respondents in the mauza were unsure of information. Some of the "mauzas" for which data were collected and which are mapped in this chapter are not true mauzas, but rather areas of accreted public land (*khas* land) that, although settled, do not form a revenue village. To make the inventory as comprehensive as possible these areas were surveyed where feasible. Near the Padma-Jamuna confluence some areas were not surveyed because they were submerged by the time of the survey or there was ambiguity over whether adjacent mauzas had extended to cover them. Given this uncertainty these areas have been shown as having "no data recorded". One mostly submerged mauza in the lower reach was omitted from the survey due to an ambiguity in the Small Area Atlas. The mauza had a population of 2,059 people in 1981 but due to bank erosion there are undoubtedly fewer people there in 1993. As in the other cases of missing data, this mauza has been colored pale green on all but the flood-related maps, on which missing data is indicated by a sandy-fawn color.

Forty-seven of the Padma study area mauzas are split either by the extensive right (west) bank embankments or by a stretch of embankment in Dohar Thana on the left (east) bank. The GIS was used to estimate the unprotected area in these mauzas; this estimate has been used to calculate the 1981 population in the study area. The inventory survey only covered the unprotected part of these mauzas. Respondents generally were familiar with the embankment alignment and appeared to make reasonable estimates of population and resources in the unprotected portion, but any data from officials had to be apportioned based on their local knowledge. Reliance on local respondents, in this case, is believed to have provided more accurate data than collecting data for whole mauzas from officials. The 1991 census data, therefore, is not directly comparable with the inventory data.

Although Figure 1.3 shows whole mauzas, including the unprotected parts, the maps in this chapter show only the unprotected part of mauzas. These maps, then, accurately represent the study area.

The questionnaire data, presented according to river reach and predominant charland type (defined in Section 1.3.2 and shown in Figure 3.1), is summarized in output tables in Appendix B. The "unprotected mainland" category in the tables includes both setback land and open floodplain adjoining the river where there are neither existing nor proposed embankments.

The tables, which cover attributes similar to those in the maps, aid map interpretation. Discerning general patterns in the maps can otherwise be difficult because of the highly variable size and irregular shape of the mauzas. Although the key informant survey method results in some uncertainty over the reliability of data, cross-checks were used to minimize this. The census and inventory data are from a 100 percent survey covering all mauzas, rather than samples, so statistical tests are not appropriate. Any differences in the resources and population between char types and reaches are the actual differences.

LAND AND POPULATION

3.2 Land and Population

3.2.1 Land Area

Based on the digitized thana maps and embankment alignments, the Padma Charland Study area constitutes 108,783 ha, including submerged mauzas. As discussed in Section 1.3.6, mauzas were categorized according to their dominant land type. Figure 3.1 and Table 3.1 combine the setback and unprotected mainland categories into one category—unprotected mainland.

Table 3.1 Study Area Size by Category (total = 108,783 ha)

Category	Area (ha)	Percent
Submerged	5,527	5
Island Char	37,156	34
Attached Char	20,523	19
Unprotected Mainland	45,578	42
Upper Reach	19,473	18
Middle Reach	51,344	47
Lower Reach	37,965	35

Source: Table B.1

The gross areas in Table 3.1 include areas under water in the 1993 dry season. Extensive areas of water are included in the island char category, therefore these mauzas comprise a high percentage of the study area. The gross areas for mauzas were obtained from the digitized Police Station maps (Figure 1.3). The upper reach is the smallest by a considerable margin, and is distinguished by a relatively narrow main channel with extensive areas of attached charland on the west bank—the area south of the Jamuna confluence.

In most cases, the gross areas of mauzas not totally submerged were used to calculate density figures; exceptions have been specifically noted. Gross areas do not change over time, and although it underestimates population density on dry season land, this calculation method, the national standard used by the Bangladesh Bureau of Statistics (BBS), makes the analysis consistent with sources such as national censuses.

Mauza areas calculated from the digitized boundaries of the Police Station maps, adjusted as necessary using the BBS Small Area Atlases and information collected from the thanas, were compared with the areas in the atlases. Fifty-seven percent of digitized mauza areas were within ± 10 percent of the BBS area, but 30 percent were more than 10 percent larger than the BBS areas, suggesting that the latter may have excluded water from the areas. The GIS estimates could be used to revise the official areas of mauzas.

The digital land type classification, derived from the 1993 Landsat imagery and shown in Figure 3.2, was correlated with the mauza data and digitized mauza map. The three land categories used were: water, sand, and cultivated or vegetated, which included land recently cultivated or vegetated. The percentages shown in Table 3.2 were cross-checked with the cultivation percentages collected in the inventory questionnaire (Table B.5); this is interpreted in Section 3.3.2.

Completely inundated mauzas cover a larger area of the upper reach (13 percent), yet the area of water is 24 percent compared with 30 percent in the middle and lower reach areas. Tables B.2,

Table 3.2 Study Area Land Type (percent)

	Land Categorization			
GIS Interpretation of Surface Type	Island Char*	Attached Char	Unprotected Mainland	All Areas
Water	47	20	15	28
Sand	22	13	4	13
Cultivated/Vegetated	31	67	81	59

Source: Tables B.1, B.2, B.3, B.4
*Includes submerged mauzas

CHARLAND CLASSIFICATION

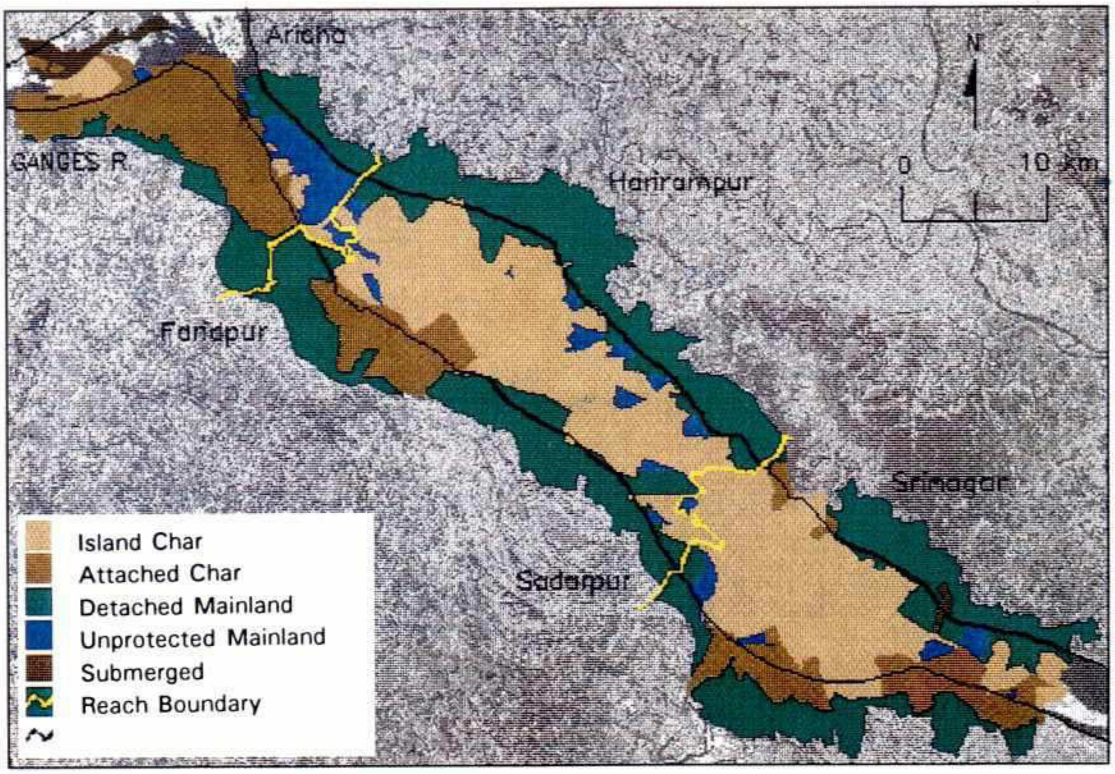


Figure 3.1

Source: Satellite image data

LAND COVER CLASSIFICATION 11 MARCH 1993

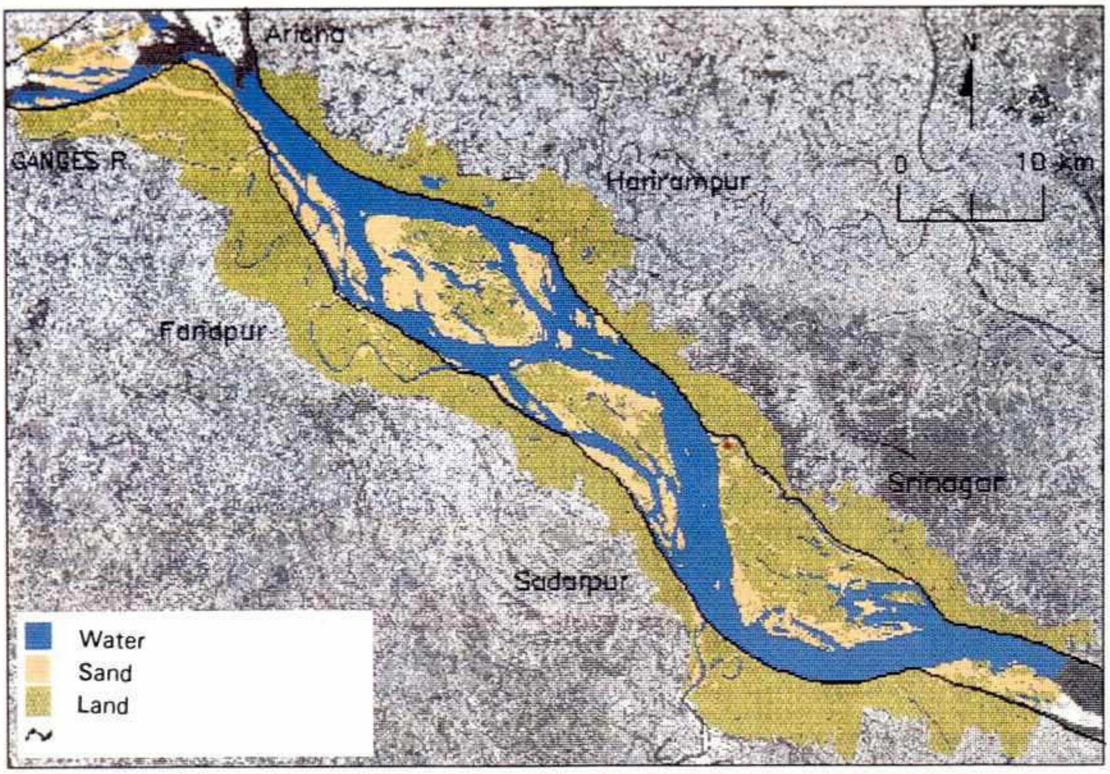


Figure 3.2

Source: Satellite image data

B.3, and B.4 are breakdowns of water, sand, and vegetated areas, respectively. Thirteen percent of the study area is sand in the dry season satellite image (69 percent of this sand is in island chars). There is much more sand visible in the Padma image than in that of the Meghna, and the percentage of sand is the same as for the Jamuna. Island char mauzas have much less cultivated or vegetated land in the dry season than other land types (Table 3.2) and are inundated in the monsoon when they form part of the normal monsoon river channel. Sand has limited economic value, so the attached chars and island chars have lower productivity per hectare of land.

The Padma RRA found that for char people catkin grass is a vital natural resource used for grazing, cut-and-carry fodder, fuel, and building material for house construction and homestead flood protection. Large parts of the vegetated areas of the island chars in the middle reach are covered in catkin grass, but some areas classified as sand grow catkin. By comparison, in the unprotected mainland there is very little uncultivated land.

3.2.2 Mauza Population Data

The 1981 population, mapped in Figure 3.3 and summarized in Tables 3.3 and B.6, is taken from the BBS National Census data (BBS Small Area Atlases) and apportioned to the mauzas lying partly in the study area (see Section 3.1). There were just over 0.58 million people living in the area in 1981, mostly in unprotected mainland.

Figures 3.3 and 3.4 show population density in 1981 and 1992, respectively. Of a total of 464 mauzas, the number of uninhabited mauzas (blue) increased from 142 in 1981 to 175 in 1993.

In 1981 the population was distributed between reaches in approximate proportion with their areas. Figure 3.3 shows that the unprotected mainland of the east bank had the highest population densities in 1981. There was a steady progression in population density from low in the island chars to medium in the attached chars and high in unprotected mainland. The lower reach had a relatively high population.

The population density in 1981 was 537 people per km^2 (including sand and water; Table 3.4), about 11 percent lower than the Bangladesh average of 605 people per km^2. Because some presently submerged island char mauzas were above water and inhabited in 1981, the tables include these mauzas in the island char category. Population densities in the island char mauzas that are not submerged in 1993 were almost the same as densities for the mauzas which became submerged, the population density was 232 people per km^2 in 1981 and 150 people per km^2 in 1993.

Figure 3.3 clearly shows low population densities (1 to 200 people per km^2; yellow in the figure) in 1981 concentrated between the 1993 banklines in the middle and lower reaches. In addition, the west bank attached chars had relatively low populations (orange). The uninhabited mauzas are almost in a straight line indicating a single main channel at that time.

Table 3.3 Study Area Population in 1981 and 1993

	1981		1993	
	Population	Percent	Population	Percent
Category	Total = 584,168		Total = 618,655	
Island Char*	98,156	17	55,630	9
Attached Char	93,612	16	92,506	15
Unprotected Mainland	392,400	67	470,519	76
Upper Reach	89,028	15	113,326	18
Middle Reach	250,797	43	296,532	48
Lower Reach	244,343	42	208,797	34

Source: Tables B.6, B.7; BBS Small Area Atlases and Charland Study Field Survey
*Includes mauzas populated in 1981 but submerged in 1993

1981 POPULATION DENSITY BY MAUZA

POPULATION PER SQ. KM IN 1981

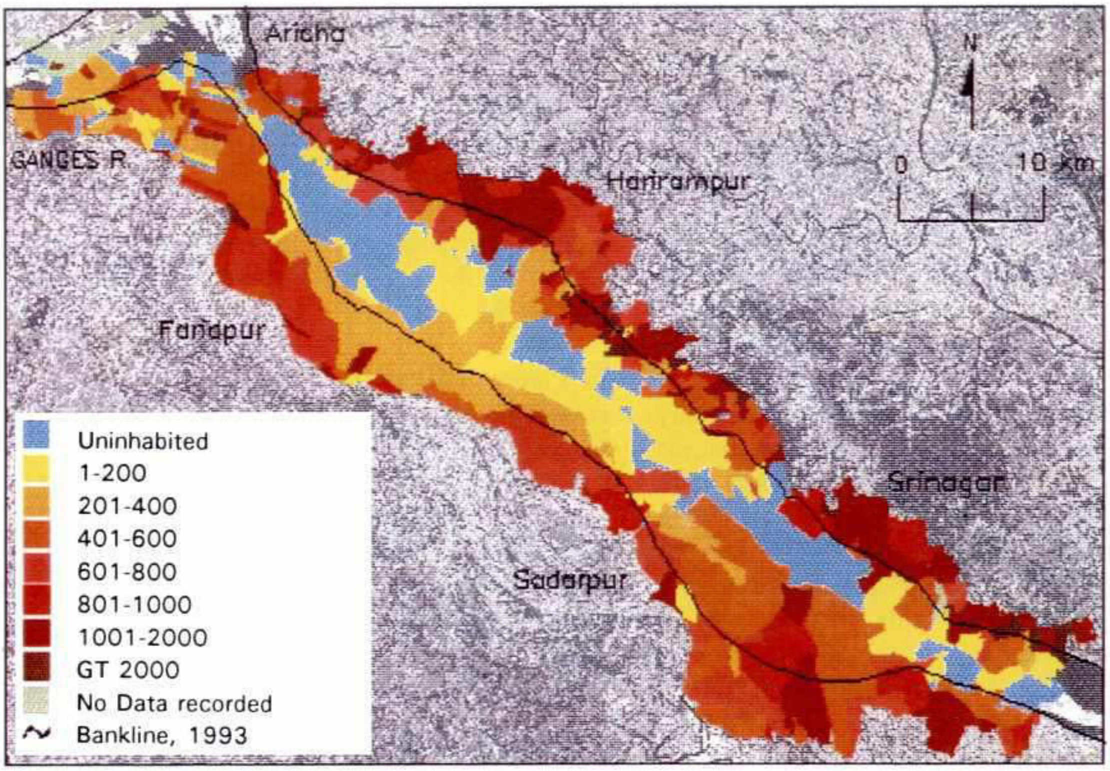


Figure 3.3

Source: Bangladesh Bureau of Statistics, 1981 census data

1993 POPULATION DENSITY BY MAUZA

POPULATION PER SQ. KM IN 1993

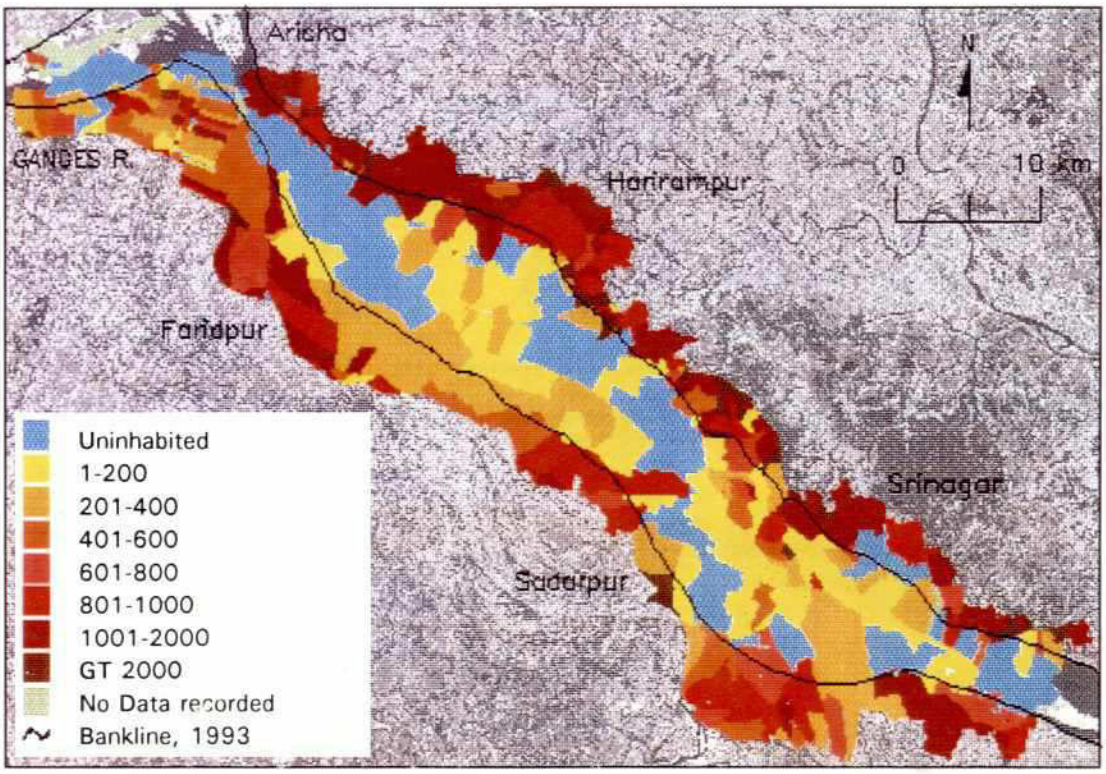


Figure 3.4

Source: ISPAN, 1993 Field data

The study area population, based on the 1993 inventory,[1] is estimated to be 618,655. Table 3.3 shows this population broken down by char type and reach based on Table B.7. The population has become more concentrated in the unprotected mainland, and 61 percent of these people are on the east bank (dark red in Figure 3.4).

The 1993 population density in the study area hardly increased above that in 1981 and was only 75 percent of the Bangladesh average of 763 people per km² (Table 3.4). In the unprotected mainland, however, population density averaged 1,032 people per km², which reflects consistently high population densities in the east bank mauzas (brown and dark red in Figure 3.4). There were also local concentrations of population on the west bank, for example, near Faridpur. If submerged mauzas are excluded the 1993 population density was 599 people per km² (Table B.8). As most of the submerged mauzas are concentrated in the upper reach, the population density is relatively higher there when these mauzas are excluded (667 people per km²).

Very low population densities (fewer than 200 people per km²; yellow in the figure) are concentrated within the banklines in the island chars (which average only 150 people per km², excluding submerged mauzas), in the upper reach in 1993 there were no people reported living in the few island char mauzas. Average densities in the attached chars are mostly 200 to 400 people per km² (pale orange), but averaged 600 people per km² in the lower reach. Variation in population density appears to be linked with land productivity, recent erosion experience, and flood risks. Comparison of Figures 3.3 and 3.4 shows the expansion of the uninhabited area in the upper and middle reaches, and a shift in the location of uninhabited mauzas in the lower reach between Sadarpur and Srinagar as the main channel swung southward.

The change in population density between 1981 and 1993 is shown in Figure 3.5 and summarized in Tables 3.4 and B.9. The study area has experienced a population increase of only 6 percent in that period, a simple average of 0.5 percent per year (Tables B.7, B.8, and B.9). The population of Bangladesh, on the other hand, increased 26 percent between the 1981 census and 1991 census (BBS, 1993). Although population in the study area has grown much less than the national average, it has experienced a complex pattern of declines and increases that appear to be related to the morphological changes shown in Chapter 2.

In Figure 3.5, yellow represents no change in population and therefore highlights the mauzas that remained uninhabited between 1981 and 1993, these are concentrated in the relatively stable single channel downstream of the Jamuna confluence. Figure 3.5 shows that areas where there has been a population decline since 1981 (blue) include:

- mauzas along the west (south) bank in the upper reach, particularly where the Ganges joins the Jamuna and the channel has shifted;

Table 3.4 Population Density and Growth 1981-1993

Category	1981 People per km²	1991/3* People per km²	Percent Change, 1981-93
Island Char	230	130	-43
Attached Char	455	450	-1
Unprotected Mainland	861	1,032	+20
Upper Reach	457	582	+27
Middle Reach	488	578	+18
Lower Reach	643	549	-15
Study Area Average	537	569	+6
Bangladesh Average	605	763	+26

Source: BBS Small Area Atlases; BBS (1993); FAP 16/19 Inventory.
*1991 population density is for the whole of Bangladesh; 1993 is for the Padma charland study area. Areas are whole mauzas including water and submerged mauzas, which accounts for the low population densities.

CHANGE IN POPULATION DENSITY 1981-1993

CHANGE IN POPULATION PER SQ. KM

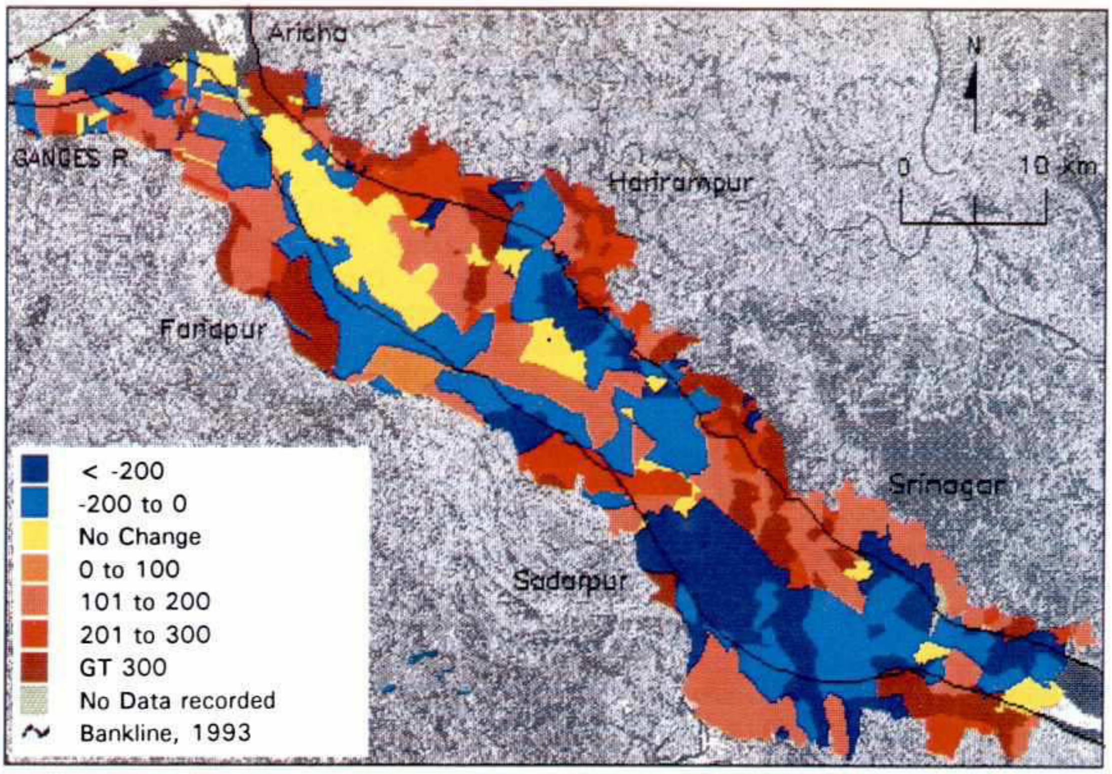


Figure 3.5

Source: ISPAN, 1993 Field data and Bangladesh Bureau of Statistics, 1981 census data

HUMAN POPULATION TO VEGETATED LAND 1993

POPULATION PER SQ. KM CULTIVATED OR VEGETATED LAND

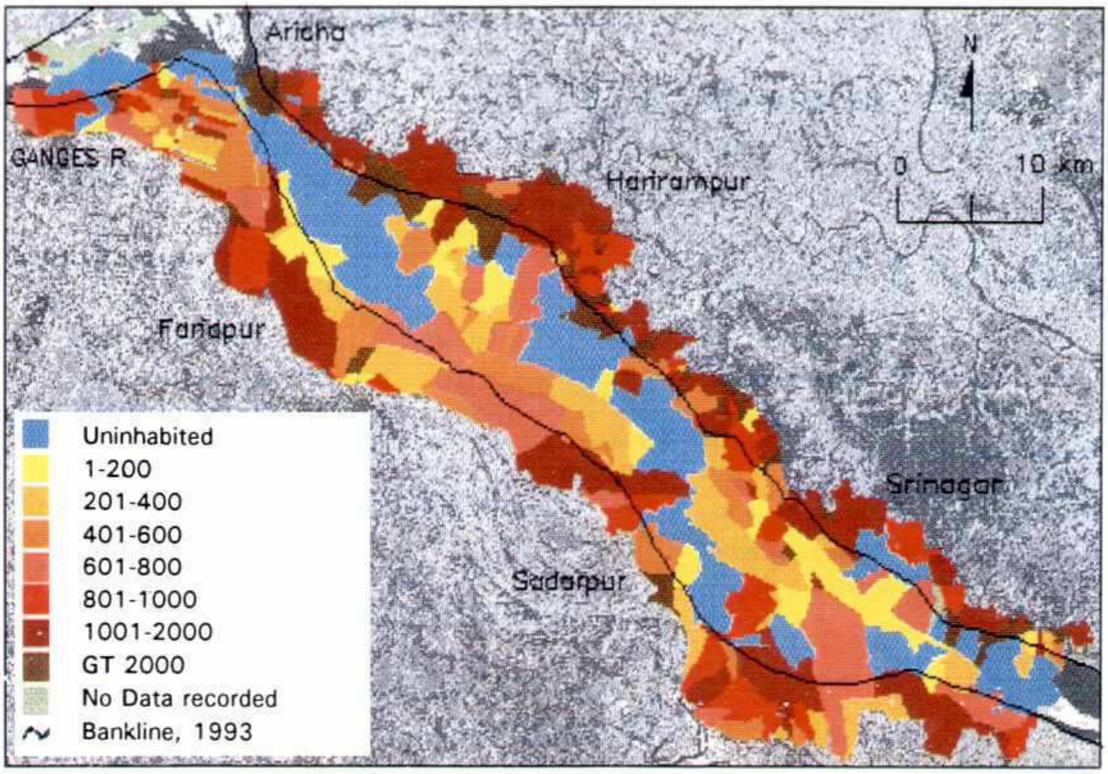


Figure 3.6

Source: ISPAN, 1993 Field data and Satellite image data

- west bank attached chars in the middle reach, and island char mauzas close to the east bank in this reach, where the channel has widened;
- island chars which have submerged in the lower reach near Sadarpur due to shifts in the main channel and a changing configuration of chars;
- east bank unprotected mainland in the lower reach where the narrow single channel of the Padma has eroded its banks; and
- a few mauzas along the southern edge of the study area which appear to have lost population, but this is probably because only the unprotected part of these mauzas was surveyed in the inventory and the riverside portion may have had lower populations in 1981 than the average for the whole of these mauzas.

Population declined in island chars throughout the river and locally in attached chars and unprotected mainland. This was associated with morphological changes to island chars within the banklines and with channel widening and consequent bank erosion.

Areas that gained the most population between 1981 and 1993 (dark red) are concentrated in unprotected mainland outside the banklines in the upper and middle reaches and in part of the west bank of the lower reach. There has also been local population growth within the banklines as island chars emerged and stabilized, particularly west of Srinagar where a large island has consolidated and is only separated from the mainland in the dry season by a relatively narrow minor channel.

Moderate population gains (200-300 people per km^2; pale red) mostly occurred in areas unaffected by bank erosion: in some of the island chars and in unprotected mainland on the west bank of the upper reach and east bank of the lower reach. There are few areas that have not been affected by erosion and accretion during this period.

Table 3.4 shows that the Padma charlands had low populations in 1981, and that population has hardly grown since then. There are large differences in the trend over the study area, which covers only about 84 km from northwest to southeast. Population growth in the upper reach has been virtually the same as in Bangladesh as a whole, although density is considerably lower than the national average. In the middle reach there has been slow growth. Population density in the lower reach was higher than the national average in 1981 but had fallen to 28 percent below the national average in 1991/3, and it is now the least populated of the Padma reaches. The low population growth reflects a combination of major loss of population from island chars, stationary population in the attached chars, and lower growth than the Bangladesh average in the most populous part of the study area (unprotected mainland). These trends appear closely related to erosion incidence (Chapter 2). The relationship between population changes and bankline changes is explored in more detail in Chapter 4.

Population densities also can be related to available dry season vegetated/cultivated land (Figure 3.6; Tables B.10 and B.11). Relating population to land use rather than gross mauza area avoids

Table 3.5 Cultivable Land Per Capita 1991/93

Land Type	Hectares Per Person	People Per km^2
Island Char	0.24	420
Attached Char	0.15	671
Unprotected Mainland	0.08	1,274
Study Area*	0.10	967
FAP 14 Char Villages‡	0.06	1,667
Bangladesh Average	0.09	1,111

Sources: Charland Study; FAP 14 (1992); BBS (1993)
*Averages for vegetated and cultivated land based on satellite image interpretation.
‡Data are from five villages, two of which were in the Padma study area, and may underestimate absentee landownership.

complications introduced by the extent of dry season water area, which is higher for island chars (Table 3.2). Although land availability is known to vary from season to season, monsoon season land areas are unknown. RRAs found that much of the agricultural and livestock economy of the study area depends on dry season land and the extent of monsoon inundation. Figure 3.6 compares population to the dry season vegetated area. This is mainly cultivated land in the attached chars and unprotected mainland, but there are large areas of useful natural vegetation (catkin grass) in the island chars.

The 1993 population relative to productive land is lower (yellow and pale orange in Figure 3.6) on average in the main river channel and west bank attached chars in the Jamuna confluence (in these areas it is rarely above 600 people per km^2). Table 3.5 shows that there is much more usable land available per capita in the island chars and somewhat more in the attached chars. Yet, overall population densities are almost the same as the Bangladesh average because of the relatively large area and high densities in the unprotected mainland. Population per km^2 of vegetated land is highest in the unprotected mainland of the upper reach where it is more than 1,400 people per km^2, and in recent years the river channel has been relatively stable.

That population density on vegetated charland is lower than the Bangladesh average presumably reflects lower land productivity, recent settlement, and the risks of flood and erosion in the main river channel. It is consistent with a relatively high proportion of vegetated land in the island chars being catkin grass and not cultivated. The few within-channel areas showing high population densities in Figure 3.6 either include areas of mainland in which most people are concentrated or settlement centers which use charland in adjacent less densely populated mauzas. The maps do not show population relative to land but relative to mauza extent.

The concentration of sand in the island chars results in much lower population densities on dry season non-flooded land (vegetated plus sand; Table B.11) than on vegetated land.

There were a total of 115,253 households in the study area in 1993 (Table B.12). Mean household size is under six people in all reaches and char types and averages 5.4 people (Table B.13). It is not clear why household size appears to be so small in the Padma area, but further analysis would require more detailed data at the household level, either from the 1991 BBS census, when it becomes available, or from household surveys.

MIGRATION

3.3 Migration

Just as the land areas of the charlands are dynamic, so to is the human population of these areas. To assess the dynamism of the charlands' human population, data on in- and out-migration were collected in each mauza for 1992. Migration, of course, can be either permanent or temporary. People move permanently because of erosion of their homesteads, to take advantage of newly accreted land, or to find work in other areas. Temporary movements are made to take advantage of seasonal economic opportunities, which may be outside the charlands (out-migration to work in urban areas, for example), or on the chars, where people can use land that is only available in the dry season (in-migration).

3.3.1 Permanent Migration

Permanent out- or in-migration (Figures 3.7 and 3.8) in the surveyed mauzas appears to be closely associated with past patterns of erosion and accretion. Out-migration was limited to a few mauzas along the banklines which were subject to bank erosion in 1992. In-migration was widespread in the island chars and in unprotected mainland and is presumed to be a response to the changing charlands shown in the satellite images in Chapter 2. It appears that in 1992 people, and therefore population levels, were still adjusting to these morphological changes. The movements may well have been local—between adjacent mauzas—as households moved to take residence where their land had accreted. The figures suggest this was particularly so in the middle reach, where movements between islands and mainland and vice versa were found to be a common response to submergence and accretion of island chars. Several mauzas here have last been settled since 1990 (Charland Study RRA).

Less than one percent (875 households) of the study area population permanently moved out of mauzas in 1992 (Tables B.14 and B.15). This migration was localized along the banklines, and one mauza in the lower reach lost its whole population in 1992 (brown in Figure 3.7). What out-migration was reported appears to have been associated with bank erosion. While some out-migration may have gone unrecorded if none were left to be interviewed for the inventory, it appears that bank erosion in 1992 was low and that few mauzas were affected so badly that people left their mauzas.

For 1992 study area mauzas reported four times more permanent in-migrations than out-migrations (Table B.16). Three percent of households present in 1993 had moved into their mauzas in the previous year (Table B.17). Permanent migration, then, is estimated to have resulted in 2.2 percent more households in 1992. In-migration was concentrated in the island chars: almost 10 percent of households had moved there in the previous year (1992) compared with 1 percent in attached chars and 3 percent in unprotected mainland. It appears, therefore, that people are moving to take advantage of newly accreted chars as they reemerge and stabilize (following widespread char erosion reported for 1987-88 in the RRA). They may also be moving into chars and unprotected mainland from areas where there has been bank erosion.

Permanent in-migration is concentrated in the middle reach (Figure 3.8), where 4 percent of households moved into their mauzas during 1992, and on island chars in the lower reach where 11 percent of households moved into their mauza in 1992. As char and bankline erosion takes place households move either to the remaining mainland or to newly accreted chars. The RRA in this reach indicated that the 1992 pattern is not an isolated occurrence, and that char formations in the middle reach frequently change, forcing inhabitants to move regularly either back and forth between island chars and temporary shelter on the mainland, or in circuits between several locations.

3.3.2 Seasonal Migration

Data were also collected on the total number of people seasonally leaving the mauza (out-migrating from their mauza of residence) or seasonally visiting the mauza (in-migrating to a temporary abode). A total of just over 7,000 people, about

SEASONAL OUT-MIGRATION

PROPORTION OF TOTAL MAUZA POPULATION, 1992

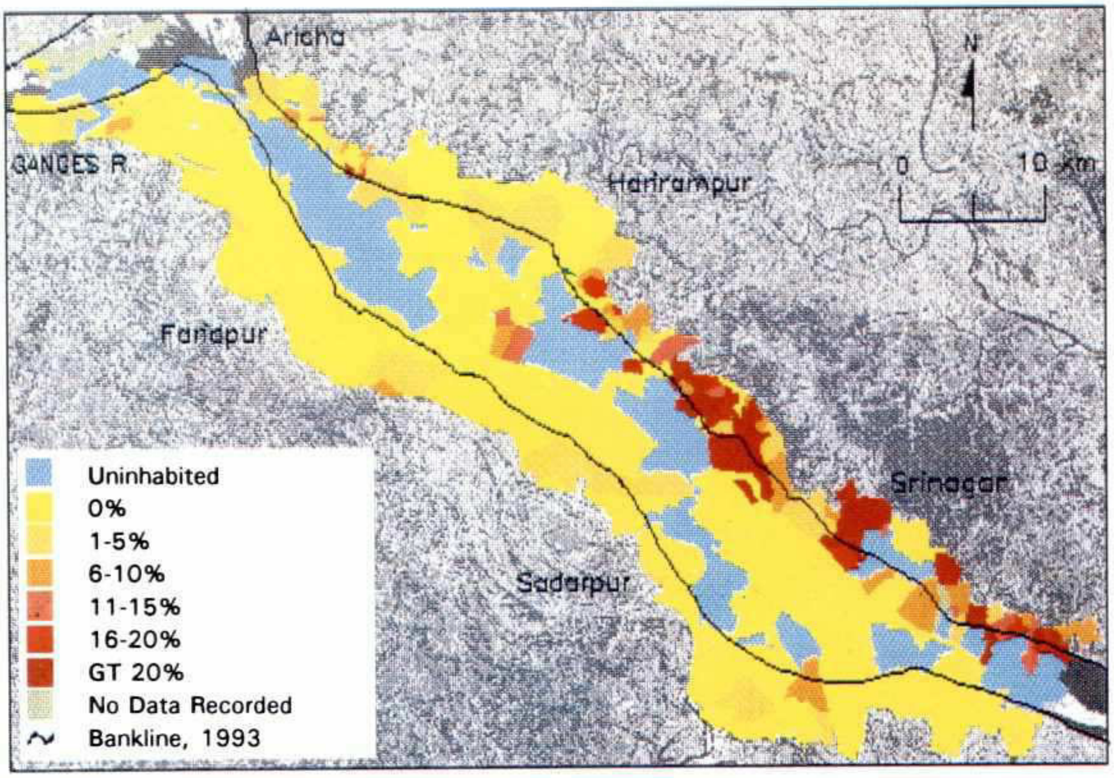
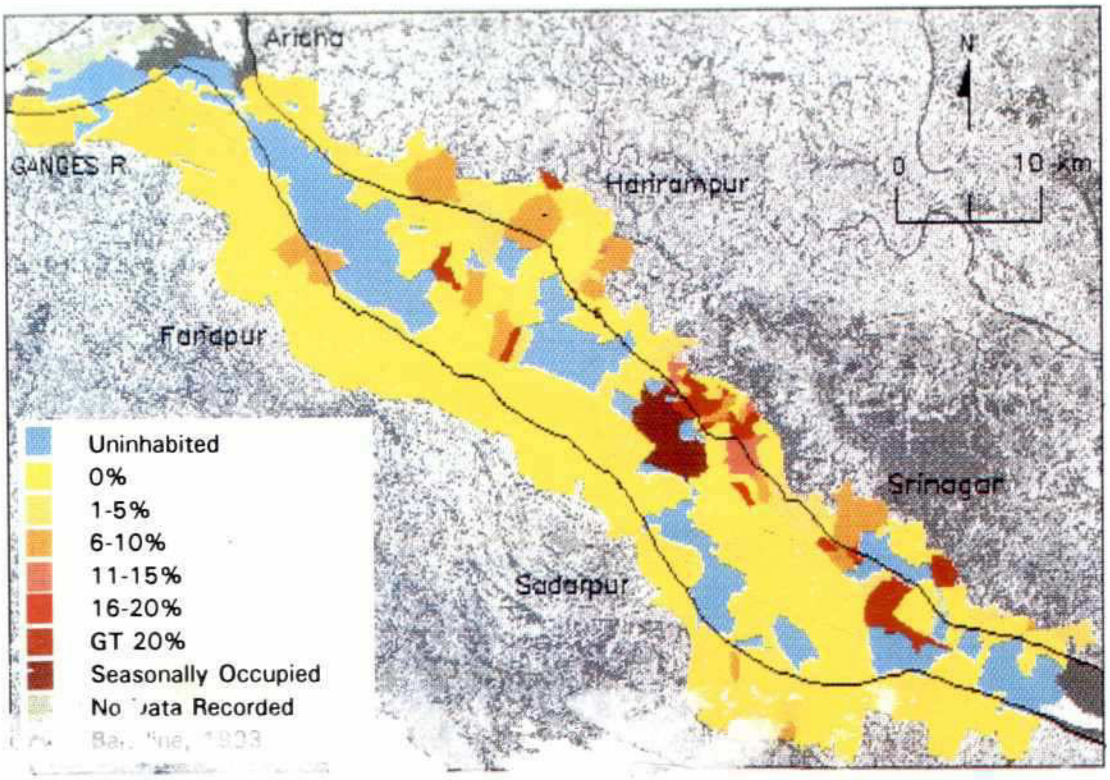


Figure 3.9

Source: ISPAN, 1993 Field data

SEASONAL IN-MIGRATION

PROPORTION OF TOTAL MAUZA POPULATION, 1992



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: ISPAN, 1993 F data

PERMANENT OUT-MIGRATION
PROPORTION OF TOTAL MAUZA POPULATION, 1992

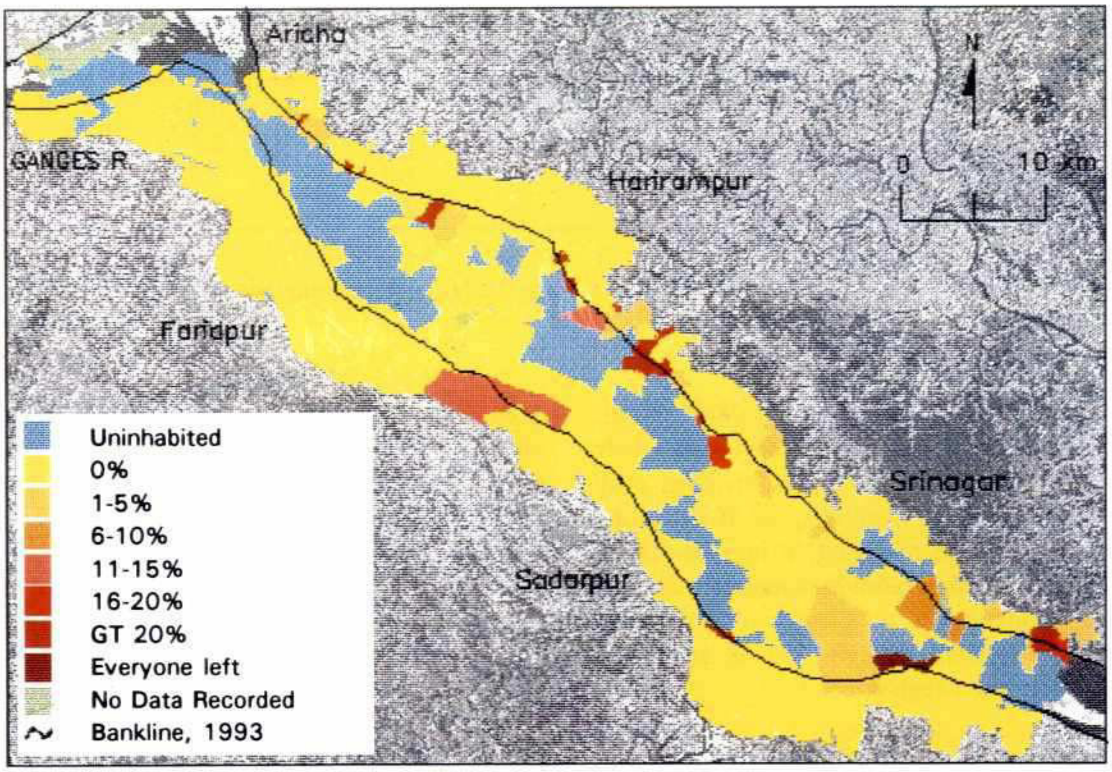

Figure 3.7

Source: ISPAN, 1993 Field data

PERMANENT IN-MIGRATION
PROPORTION OF TOTAL MAUZA POPULATION, 1992

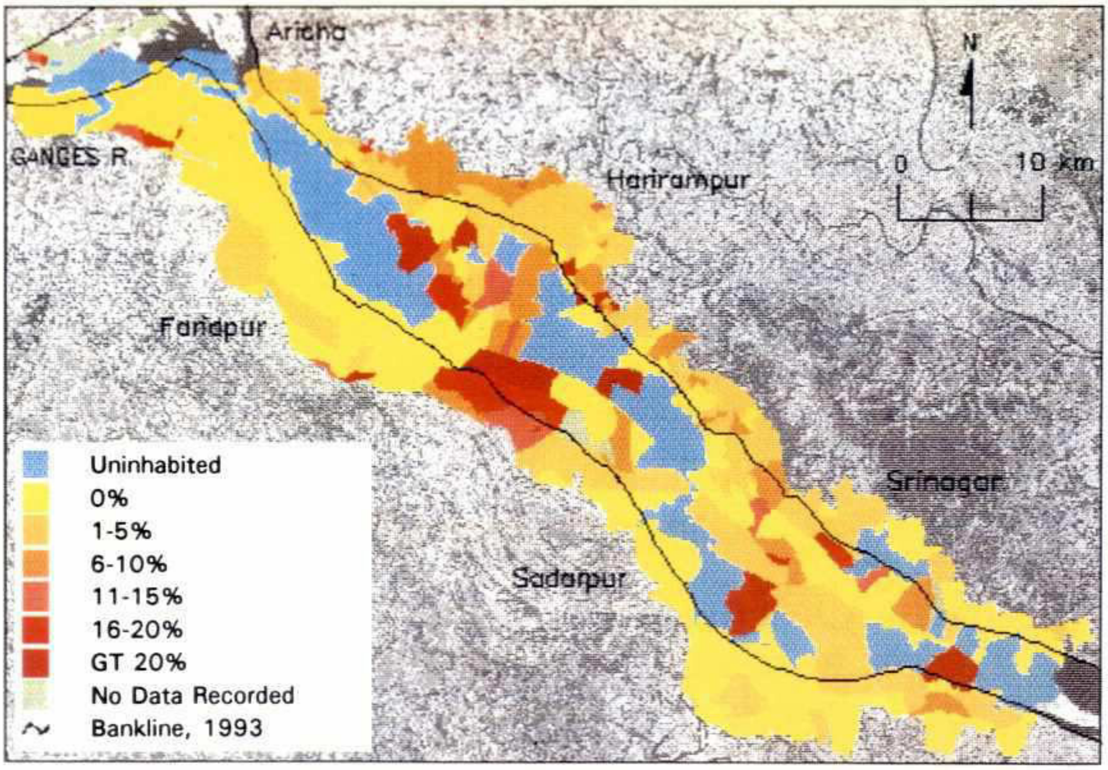

Figure 3.8

Source: ISPAN, 1993 Field data

Table 3.6 **Incidence of Migration in 1992 (percent of total households)**

Type of Migration*	Island Chars	Attached Chars	Unprotected Mainland	Total
Permanent Out-migration	0.9	0.9	0.8	0.8
Permanent In-migration	9.8	1.3	2.7	3.2
Seasonal Out-migration	3.0	1.0	7.7	6.2
Seasonal In-migration	1.8	0.0	2.4	1.9

Source: Tables B.14 to B.21.

*Permanent migrants are households a percentage of all households; seasonal migrants are individuals expressed as a percentage of households.

1.2 percent of the 1993 population (Tables 3.6, B.18, and B.19), temporarily migrated out of their mauzas. Seasonal migration often involves only some male household members, so if only one person per household migrated, it implies that in about 6 percent of households someone migrated out. The incidence of temporary out-migration may well be underestimated, but is still high compared with the Meghna.

Most mauzas did not report any seasonal out-migrants, and there were very few migrants in the upper reach. Figure 3.9 indicates a concentration on the east bank of the middle and lower reaches, in the latter 29 percent of households may have sent someone to work outside the mauza. Several factors appear to be behind this concentration:

- in the middle reach in Dohar Thana nearby island char mauzas are only occupied seasonally for cultivation (Figure 3.10)—these people are likely to be the same out-migrants shown for nearby mauzas in Figure 3.9;
- many households displaced by bank erosion have taken shelter in these areas (see Section 3.6.3) and are forced to send people outside the area to find work; and
- Mawa, which is included in this area, has good road connections with Dhaka that make seasonal out-migration to find urban work easy.

There were 70 percent fewer seasonal in-migrants than out-migrants in the study area in 1992 (Figure 3.10; Tables 3.6, B.20, and B.21). There was virtually no in-migration in west bank mauzas, most was located adjacent to or in the same mauzas as seasonal out-migration. In most cases seasonal migrants seem to move to newly accreted island chars that are too low for permanent settlement but can be cultivated during the dry season. This is the case in the middle reach mauzas colored red-brown in Figure 3.10, which, although not permanently inhabited (and therefore colored pale blue in the other maps), are cultivated in the dry season by temporary settlers (seasonally out-migrating from nearby mauzas).

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SERVICE AND INFRASTRUCTURE PROVISION

3.4 Service and Infrastructure Provision

Among the inventory data collected was information on the type and level of services provided to people. Only education and health services are mapped since these are the most important government service issues in the charlands, according to case studies conducted by FAP 14 and FAP 3.1. No attempt was made to obtain size details of the education and health facilities. The distribution patterns of school and health facilities are expressed as the number of people in the mauza theoretically served by the facility. The maps disregard the fact that many facilities have cross-mauza catchments. Moreover, access to many facilities is likely to be uneven due to communications difficulties in both dry and wet seasons. The RRA case studies show that transport problems limit the achieved charland catchments of high schools and health facilities.

3.4.1 Schools

A total of 159 mauzas (51 percent of inhabited mauzas) were reported to have primary schools (Tables 3.7 and B.22). Figure 3.11 shows that they are widely spread across the study area. Nonetheless, almost half of the inhabited mauzas have no primary school, and coverage is worst in the island and attached chars where more than 50 percent of mauzas have no school (yellow). Given the frequent erosion and accretion and associated population shifts in the middle and lower reach island chars, the lack of schools is understandable. Some children may be able to attend schools in adjacent mauzas but for many there appears to be no primary education opportunity in the area, this includes some mainland areas, particularly in the upper reach west bank and middle reach east bank.

There are, the survey found, many fewer secondary education opportunities (high schools) in the Padma charlands. Figure 3.12 shows 58 high schools in the study area (Table B.23). Surprisingly six high schools were reported in island char mauzas, but in most cases these mauzas include areas of mainland where these schools are presumably located. In the upper reach there are about 14,000 people per high school, but there are about 10,000 per school in the middle and lower reaches. Many potential students in the chars, however, are separated from high schools by main river channels and distances of 10 km or more.

The age range for primary school children is six to 10 and for high school children, 10 to 15. The 1981 census of Bangladesh found that 16.3 percent of the country's population was between the ages of five and nine (the age range closest to that of primary schools) and 13.4 percent was between 10 and 14 years old (the age group closest to that of high schools). Assuming that these percentages still apply to the study area—and to Bangladesh—implies that in 1993 the study area had 100,800 children between five and nine years old and 82,900 in the 10-to-14 age range. For the study area this amounts to an average of 634 children per primary school (compared with 372 per primary school for all of Bangladesh) and 1,429 children per high school (compared with a

Table 3.7 Health and Education Services Provided to Inhabited Mauzas

Charland Type	Number of Mauzas	Inhabited Mauzas	Primary School (%)	High School (%)	Health Facility (%)
Island Char	125	55	45	16	2
Attached Char	82	62	41	10	8
Unprotected Mainland	218	195	55	22	23
Total	484	312	51	19	16

Source: Tables B.22 to B.24.

PRIMARY SCHOOLS BY MAUZA

TOTAL POPULATION PER SCHOOL

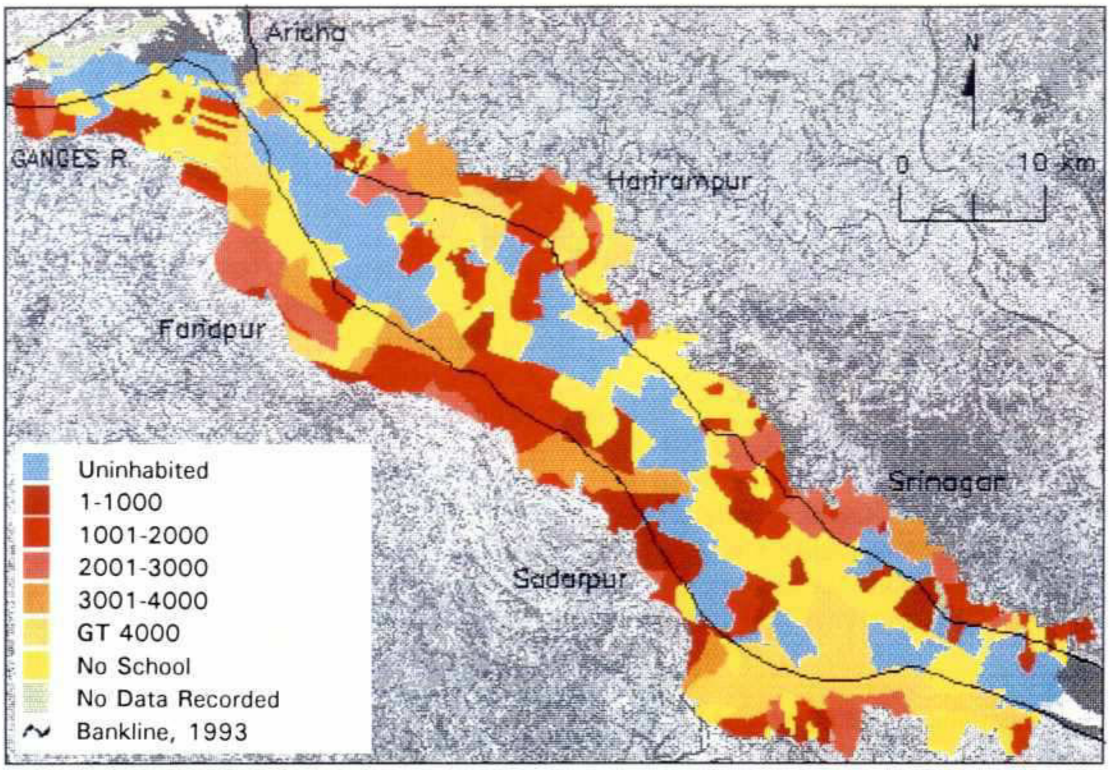

Figure 3.11

Source: ISPAN, 1993 Field data

HIGH SCHOOLS BY MAUZA

TOTAL POPULATION PER SCHOOL

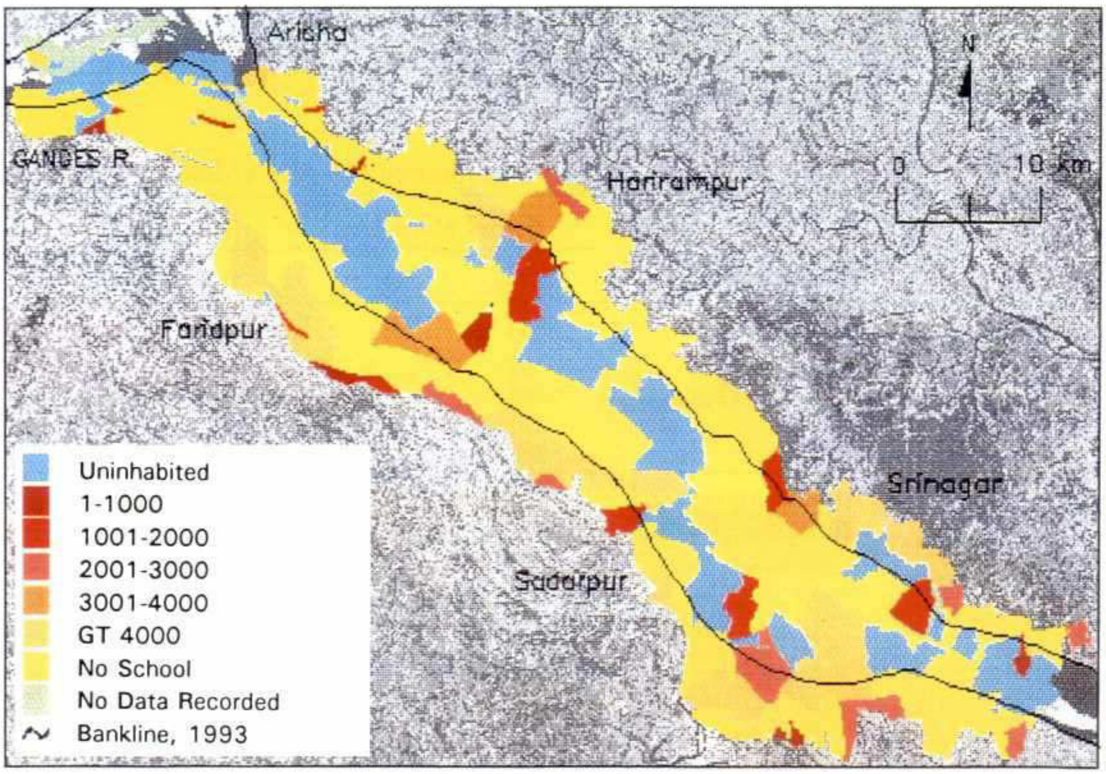

Figure 3.12

Source: ISPAN, 1993 Field data

Bangladesh average of 1,513). There is, therefore, a lack of primary school facilities in the Padma charlands compared with the national average and Jamuna charlands. Although high school coverage is up to the national standard, the existence of a school does not ensure that education is available. Transport problems prevent char children from attending schools. In many char schools in the middle Jamuna teachers were absent or had not been posted (FAP 3.1, 1993), and presumably the same problems occur in the Padma chars.

3.4.2 Health Care

Figure 3.13 shows there are 50 mauzas (16 percent; Tables 3.7 and B.24) with health care facilities in the study area. Health facilities were defined as physical infrastructure (either a government hospital, health care center, or family planning center or an NGO health care facility) present in the mauza.

Provision, the survey found, is relatively good but is biased toward the more stable unprotected mainland where there are only about 10,000 people per facility compared with more than 14,000 per facility in the lower reach (Tables 3.7 and B.24). The study area has only 12,400 people per hospital or health care center, which appears to be considerably better than the national average. In 1991 there were 2,819 government and non-government health care facilities (BBS, 1993)—only about one facility for every 38,980 people. The difference in the Padma charlands may be due to a high level of NGO activity (see Section 3.4.4), and inclusion of facilities not included in the BBS data. Despite the appearance of adequate coverage, many people in island chars live about 10 km from the nearest medical facility and must travel long distances by foot and boat in the dry season or by boat in the monsoon season to take advantage of the service.

Key informants were also asked when their mauza had last been visited by a health worker (Figure 3.14). Of all inhabited mauzas, 77 percent were visited in the first half of 1993 prior to the field survey (red), and an additional 10 percent had been visited in 1992 (pink). Only 11 percent of inhabited mauzas were never visited (or informants do not remember when they were last visited; yellow on the map), but most of these had been visited by a family welfare worker and therefore may have received similar services. Coverage even of island chars appears to be good, so it is surprising that some mainland mauzas appear not to have been visited.

3.4.3 Water Supply

One fundamental means of preventing illness is to have a secure and pure source of drinking water. Under normal monsoon conditions, 95 percent of households in the study area reportedly use hand tubewells (HTW) for drinking water, 4 percent use the river, and about 1 percent use ponds, *khals*, and wells. Table 3.8 shows that even in the island chars under normal conditions there is good access to HTWs, although 11 percent of households usually drink river water.

Table 3.8 shows a complete reversal of drinking water sources during the 1988 flood, when 74 percent of study area households drank river or flood water but 86 percent of attached char house-

Table 3.8 Drinking Water Source (percent of households)

	Normal Monsoon		1988 Flood	
Land Category	HTW	River	HTW	River
Island Char	87	11	18	81
Attached Char	97	5	13	86
Unprotected Mainland	95	3	29	71
All Areas*	95	4	25	74

Source: FAP 16/19 Field Survey

*The remaining households (less than 2 percent before rounding) used pond or dug wells for water. Data for 1988 are only from those mauzas which were inhabited in both 1988 and 1993.

HEALTH FACILITIES BY MAUZA

TOTAL POPULATION PER HEALTH FACILITY

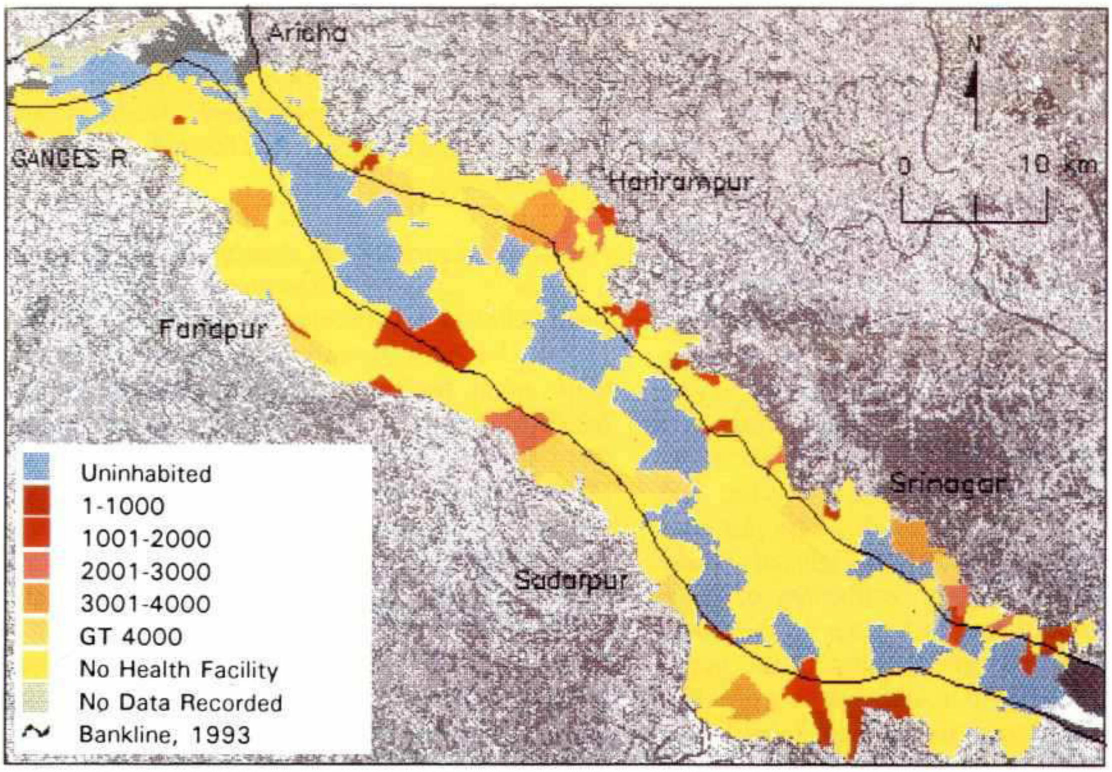

Figure 3.13

Source: ISPAN, 1993 Field data

LAST VISIT BY HEALTH WORKER

YEAR OF VISIT

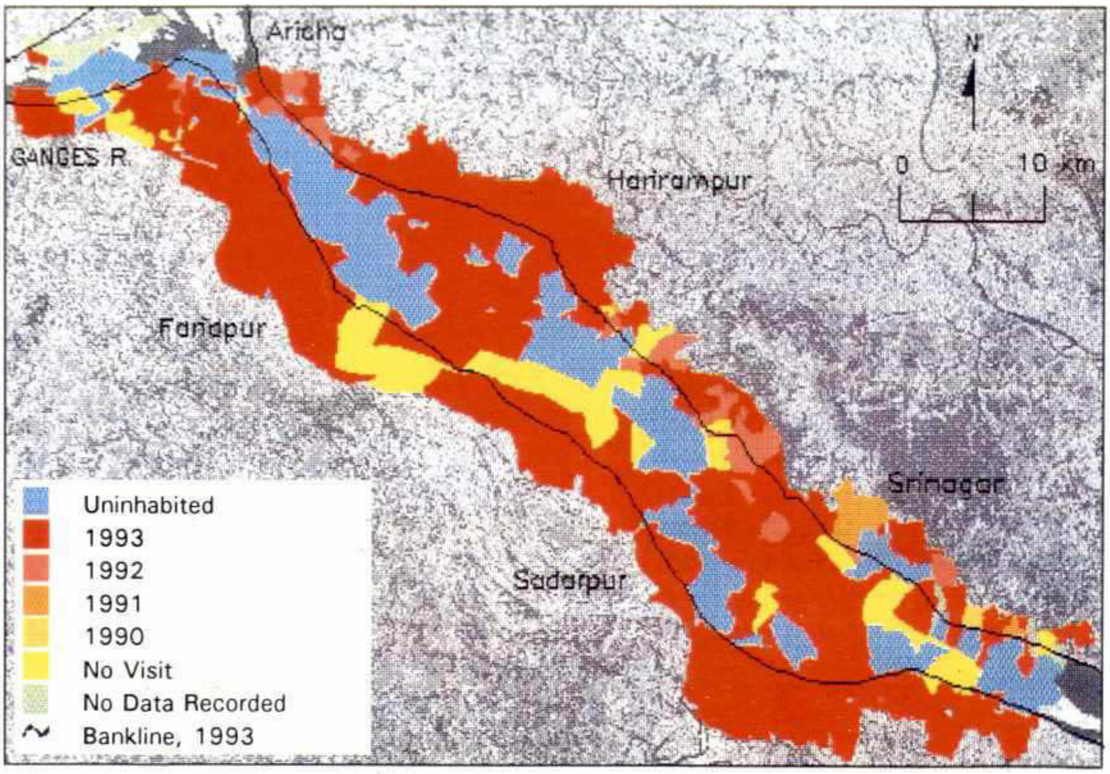

Figure 3.14

Source: ISPAN, 1993 Field data

holds were forced to drink river or flood water. The mainland people were slightly less affected, with 29 percent continuing to use HTW water during the flood. Thus, the island char people are disadvantaged in terms of their access to pure drinking water.

3.4.4 Other Infrastructure

The distribution of markets in the study area was also investigated. There are a total of 62 mauzas (20 percent of inhabited mauzas) with periodic markets (*hats*). Most of those mauzas also have a bazaar with some permanent shops. *Hats* and bazaars appear to be scarce in the upper reach where only one mauza in 10 has a market, and more common in the lower reach where just over one mauza in three has a market. Eighteen mauzas had major markets. Again, availability of these market facilities is somewhat better in the lower reach. The lack of larger markets in the upper reach, which has only four, may not be a problem since this reach is close to the main ferry routes connecting the southwest with Dhaka via Aricha.

Rural electricity supplies are scarce in the Padma charlands, only 44 mauzas (14 percent of inhabited mauzas) have electricity, and these are concentrated in the unprotected mainland (89 percent), particularly in the lower reach. The one island char mauza that has electricity includes an area of mainland; the islands themselves do not have electricity.

Other inventory data on infrastructure will be useful in planning improved access to facilities and designing income-generating programs for the char people in specific areas. However, compared with the Jamuna and Meghna charlands, the Padma charlands are already well covered by non-government development programs. At present 49 percent of inhabited mauzas are reported to be the target of NGO activities, although in some cases this may only indicate past relief activity. These programs are concentrated in the middle reach where 72 percent of mauzas are host to NGO activities. Although NGOs concentrate on the mainland areas (where they cover 62 percent of mauzas), 27 percent of island char mauzas report having some NGO activity. Given the extent of erosion and morphological changes in the river, it is important that the NGOs avoid putting their scarce resources into "permanent" facilities that may then be washed away, and instead concentrate on human capital.

Access to the local power structure is important as a means of directing infrastructure, services, and flood relief to a particular mauza. People in the Padma charlands appear to have good access to their union parishad chairman: 13 percent of inhabited mauzas have a chairman resident. Since there are an average of 13 mauzas per union in Bangladesh, the norm is for 7.7 percent of mauzas to host their chairman.[2] The island chars are not as well represented in union parishads—only 9 percent of them have a chairman resident (although the distribution of ward members was not assessed). The upper reach had few chairmen present in study area mauzas (6 percent have a chairman living there), but there are fewer whole mauzas in the study area in this reach.

RESOURCE AVAILABILITY AND USE

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3.5 Resource Availability and Use

3.5.1 Occupations and Overall Resource Base

This section documents a high dependence on cultivation, particularly monsoon season paddy, but also dry-land crops, in the Padma chars. Livestock are also a key part of this economy, reflecting the charlands' abundant grazing, although as will be seen, this does not result in higher densities of animals per hectare. The Padma is more important for commercial fishing than the Jamuna but much less significant than the Meghna, as national statistics (BBS, 1993) show, but fishing is still an important occupation. Many people own boats, river transport being an important resource both for normal communications and for evacuation when erosion and floods force people to leave their homes. The pattern of competition and social conflict for the changing land resource is complex, and these issues have been further studied during the rapid rural appraisal (RRA).

Forty-three percent of households reported agriculture as their primary occupation (Table 3.9). Dependence on agriculture (cultivation of own land) was consistently higher on west bank unprotected mainland in all three reaches; it was highest in the upper reach (62 percent of households) and lowest (29 percent) in the lower reach east bank unprotected mainland (Tables B.25 and B.26). In the latter area business, trade, and labor are relatively important.

Compared with the Jamuna charlands fewer Padma households are dependent on day labor, which is primarily agricultural work. Day labor is most important in the attached chars, where there is less fishing and less involvement in business. The occupational structure in the Padma charlands is similar to that found by FAP 14 in a wider range of flood environments. There is relatively high involvement in business (Tables 3.9 and B.30) in the study area compared with the Jamuna and Meghna charlands. A higher percentage of households live in the mainland areas than in the charlands of the other rivers, but the area is also close to the town of Faridpur, and there are two routes to Dhaka (from Aricha and Mawa) from the study area.

Table 3.9 Main Occupations of Charland Households (percent)

Occupation	Island Char	Attached Char	Unprotected Mainland	Study Area	FAP 14 Average
Farming	44	40	43	43	38
Day Labor	24	38	29	30	30
Fishing	20	11	5	8	6
Business	8	8	12	11	8
Service	1	1	3	2	7
Other*	3	2	8	6	11
Total Households	10,690	18,875	85,688	115,253	7,723
Percent Fishing for Second Income	20	16	8	11	na

Source: Table B.30; FAP 14 Final Report

*Consists mainly of households engaged in paid domestic work or receiving external remittances.

The surveys concentrated on land-based resources because the methodology was inappropriate for a detailed investigation of fisheries. Nevertheless, fishing is the main occupation of 8 percent of households, and another 11 percent fish as a secondary income source (Tables B.27, B.28, and B.29). In the island chars dependence on fishing is much higher: 20 percent of all households fish as a primary occupation and 20 percent do so as a secondary occupation. Fishing is also relatively important in the attached chars (which border the main channel): 11 percent of households fish as a primary occupation and 16 percent as a secondary occupation.

The RRA in the middle reach concentrated on island and attached chars and found more professional fishermen than the inventory did (57 percent of households reported fishing to earn income at some time in the year). The inventory probably underestimates the number of households fishing seasonally and selling their catch since many char households use traps (*duars*) rather than nets, and may not have been counted in the inventory surveys; other households may have members employed as laborers or working on a share basis for fishing gear owners and could also have been omitted.

These figures show a somewhat higher dependence on fishing than the 6 percent of households mainly fishing in five char villages studied by FAP 14 (FAP 14, 1992), which included two villages in the Padma. National statistics (BBS, 1993) show that in 1988-89 the Padma contributed only 2 percent of the total main river catch (including the Lower Meghna) and 9 percent of the total main river catch (excluding the Lower Meghna). Fishing employment in the Padma charlands then is more important than might be expected from the total catch reported from the river.

3.5.2 Agriculture

As Section 3.2.1 explains, cultivated areas were mapped using the mauza questionnaire returns (Figure 3.15; Table B.5) and interpretation of satellite imagery (Figure 3.2). The Padma inventory questionnaire tried to improve respondents' accuracy in estimating cultivated area by calculating land area separately and having them estimate the total percentage of dry season land area cultivated at any time during the year. Comparison of the two estimates (Tables B.4 and B.5) indicates that respondents' estimates of cultivated area are 8 percent higher than the image estimate of vegetated area. This discrepancy is almost entirely because the inventory estimates indicate that 59 percent more island char land is cultivated than was estimated as vegetated or cultivated from the satellite image, implying that all vegetated land plus all sand in the chars is productive. There are probably two reasons for this: first, the respondents and survey teams counted catkin grass as cultivation since the grassland areas are harvested on a commercial basis and form an important component of the Padma charland production systems, and second, groundnuts (which are sown relatively late in this area) are a major crop (see below) and sparsely cultivated areas may have been interpreted as sand in the January 1993 satellite image.

Figure 3.15 shows that a high percentage of study area land is cultivated. The 40 submerged mauzas (blue) are all uninhabited (pale blue in the previous figures) and were completely submerged during the 1993 dry season. Pressure to use land resources is high, but 52 more mauzas have land but are not cultivated (yellow)—these are again uninhabited and mainly comprise small areas of sandy chars. Most of the other uninhabited mauzas have less than 50 percent of land cultivated (pale green), are within the channel, and correlate with areas of seasonal in-migration.

In 41 percent of cultivated mauzas more than 80 percent of land is cultivated (dark green in Figure 3.15). Cultivation is particularly extensive in the west bank unprotected mainland and in east bank unprotected mainland in the upper reach. Somewhat surprisingly a high percentage of land is also cultivated in two of the three island char complexes: in Harirampur Thana (upstream islands) and in Srinagar Thana (downstream islands, which are more stable), which is the reason for the high estimate of cultivated area reported above.

Cropping intensity measures the extent to which land is multiple cropped within a year. A 100 percent intensity means that all cultivable land grows an average of one crop per year, a 200 percent intensity means that an average of two crops a year are grown.[3] Most cultivable land grows at least one crop a year in Bangladesh, and the study area is no exception. In the 12 percent of cultivated mauzas with intensities of up to 100 percent (pale brown in Figure 3.16) almost all were in the 95-100 percent range indicating single cropping with small areas of fallow in any one year. These areas are concentrated in the island chars of the upper reach and in lower reach east bank unprotected mainland. The low cropping intensity in the latter area is unexpected and may deserve further study.

Table 3.10 Cropping Intensity

Land Type	Cropping Intensity (percent)
Island Char	162
Attached Char	190
Unprotected Mainland	179
All Land	178

Source: Table B.31

Average cropping intensities are relatively high (over 162 percent) for all three char types and reaches (Table 3.10) with an overall average of 178 percent, and are similar for all the land types, but this masks local variations (Table B.31). Figure 3.16 shows that mauzas with a cropping intensity of more than 200 percent (darker green) are concentrated in the unprotected mainland and attached chars of the west bank (especially in the upper and middle reaches) and in unprotected

PROPORTION OF LAND CULTIVATED BY MAUZA

PROPORTION CULTIVATED IN 1992

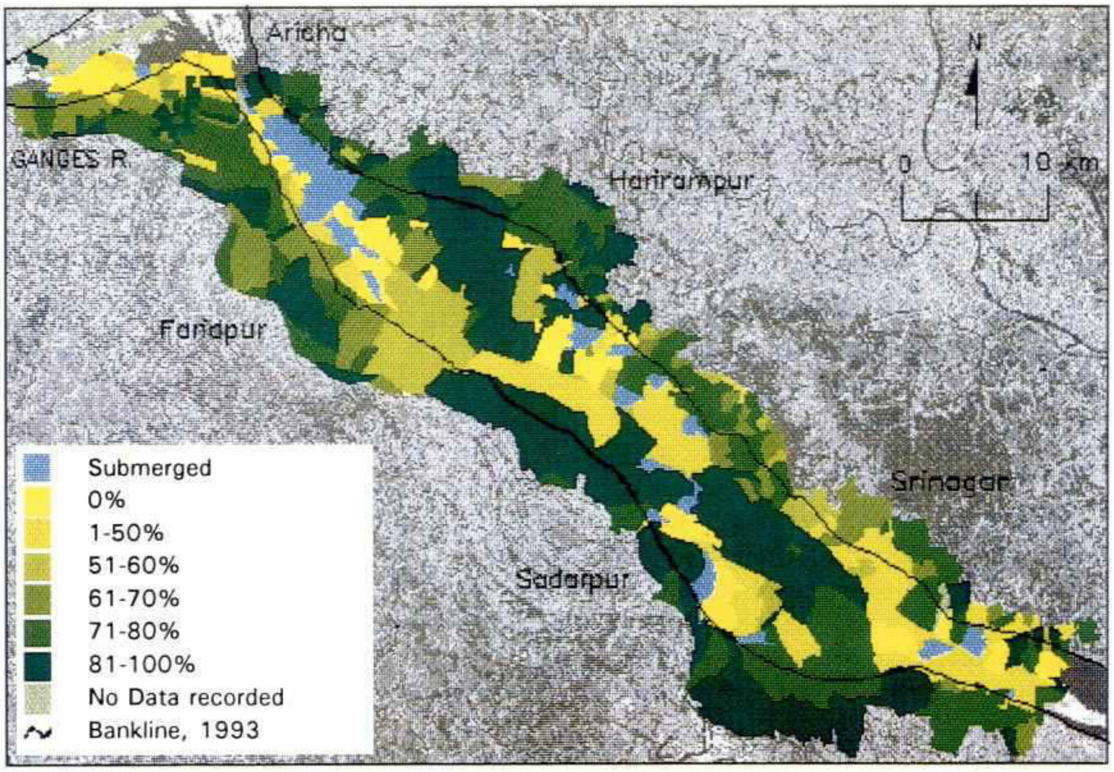

Figure 3.15

Source: ISPAN, 1993 Field data

CROPPING INTENSITY

PROPORTION OF CULTIVABLE LAND CULTIVATED IN A YEAR

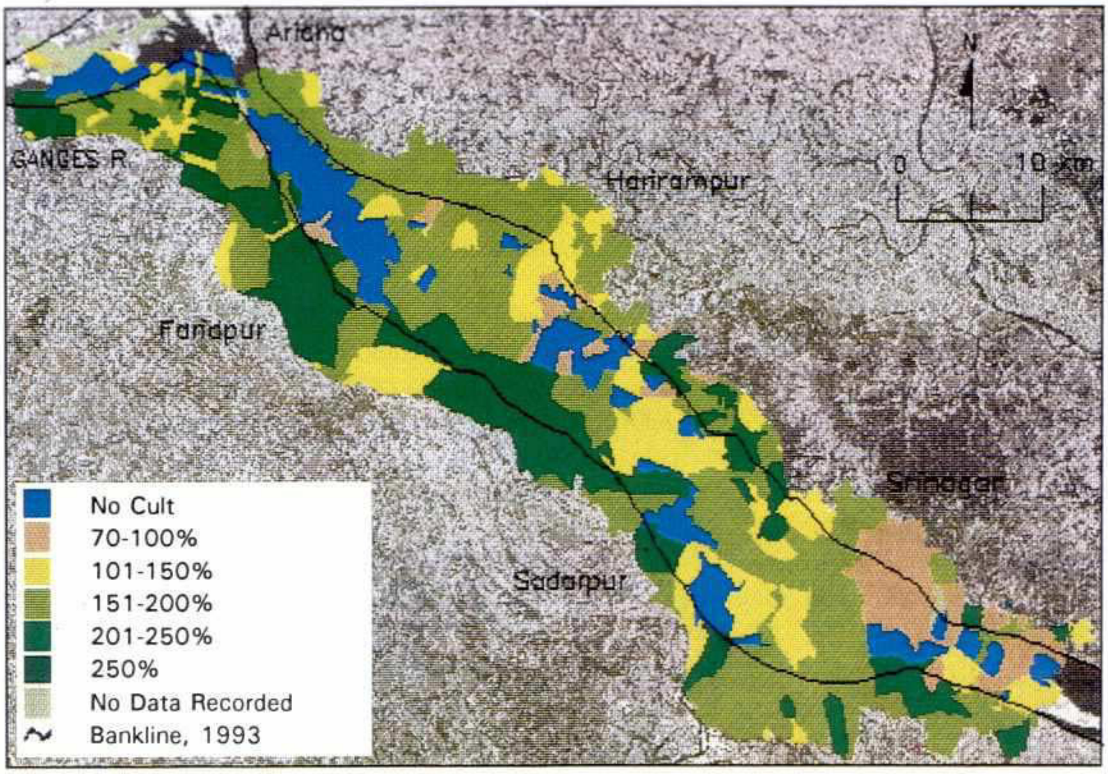

Figure 3.16

Source: ISPAN, 1993 Field data

mainland in the east bank middle reach. This is relatively older land but not the oldest and most stable land, which Figure 2.10 showed is mainly along the mainland fringe of the east bank. By comparison, many within-channel mauzas have lower than average cropping intensities. The lowest intensities are on the island chars and, unusually, on east bank unprotected mainland in the lower reach.

Land stability, monsoon water levels, and flood risks are among the factors determining a farmer's choice of crops and, therefore, the intensity of cultivation, but in the Jamuna chars sand and dry-land cropping were also found to be important. The Padma inventory obtained estimates of the percentage of land that is sandy (*bele*), loam (*doas*), or clay (*etel*) in each mauza. Figure 3.17 shows that only in areas of unprotected mainland—mainly on the east bank—was sandy soil virtually absent. Averaged over the whole study area sandy soil was much more common than in the Meghna area: on average, 35 percent of soil was sandy (Table B.32).

Sandy soil is concentrated in the main channel throughout its length, but there is a clear north-south trend from 45 percent in the upper reach to 28 percent in the lower reach. Island chars have the most sand, reaching a peak of 91 percent sand in the upper reach, and average 60 percent sand throughout the Padma (Table 3.11). Thus the dominance of sandy soils in the Jamuna and Ganges charlands continues into the Padma but gradually declines. The Padma-Meghna confluence island chars are similarly sandy, but the rest of the Meghna charlands are much less so.

The influence of sandy soil on cultivation should be most apparent in the extent to which dry-land crops (millets, groundnuts, and sweet potatoes) are grown. Figure 3.18 shows a generally low coverage of these crops, and an absence of them (pale brown) in the mainland fringe of both banks, particularly where sand is absent on the east bank and in some gaps within the banklines. Some of the sandiest mauzas are uncultivated (blue) and are presumably pure sand. Millets are virtually absent

Table 3.11 Percentage of Sandy Soil

Char Type	% Sand
Island Char	60
Attached Char	44
Unprotected Mainland	17
Total	35

Source: Table B.32

from the Padma chars (1 percent of cultivated land, Table B.33) unlike the Jamuna chars where they are some of the most important crops. Sweet potatoes similarly are rare in the Padma chars, yet locally they are important on sandy island chars in the Upper Meghna. Agronomic study to determine whether these crops would give good returns in the Padma chars might be worthwhile.

Groundnuts are widely grown in the island and attached chars (21 and 16 percent of cultivated land, respectively) and account for most of the dry-land crop area in Figure 3.18 and Table 3.12. They are mainly grown in the island chars of the middle and lower reaches in a chain following the alignment of the main channel, and in some of the west bank attached chars. Table B.34 shows relatively good yields reported for groundnuts in the island chars. Hence their absence from some island chars would deserve further investigation. The findings are consistent with the RRA in the middle reach where it was reported that the area cultivated with groundnuts had increased in the past decade, but that the crop was sometimes damaged by early floods.

A wide range of other crops are also grown during the winter, including wheat and other rabi (winter season) crops and winter-sown boro paddy. Of the rabi crops, excluding winter paddy, wheat is the single most important crop and covers 13 percent of cultivated land. It is mostly grown in the upper reach and unprotected mainland (Table 3.12). Local and high yielding varieties (HYV) of boro paddy are grown on 20 percent of the cultivated land. Boro cultivation is concentrated in the

EXTENT OF SANDY SOIL

PROPORTION OF SOIL REPORTED SANDY

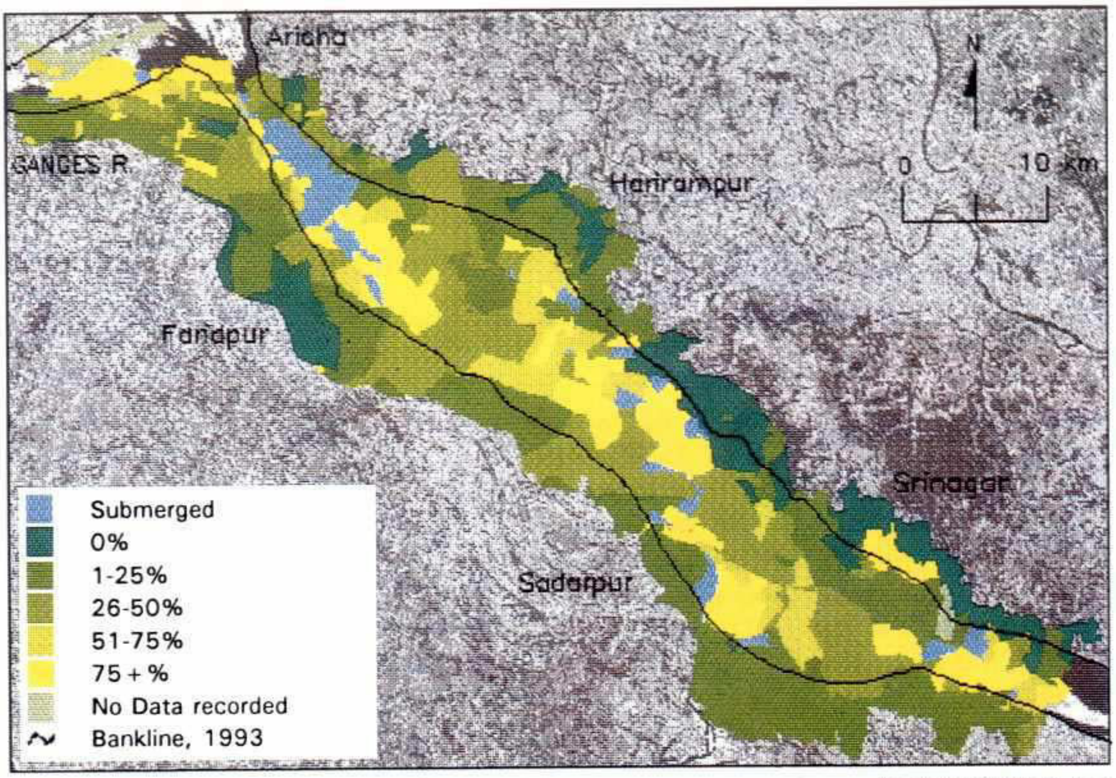

Figure 3.17

Source: ISPAN, 1993 Field data

DRYLAND CROP COVER

PROPORTION OF CULTIVABLE LAND UNDER DRYLAND CROPS

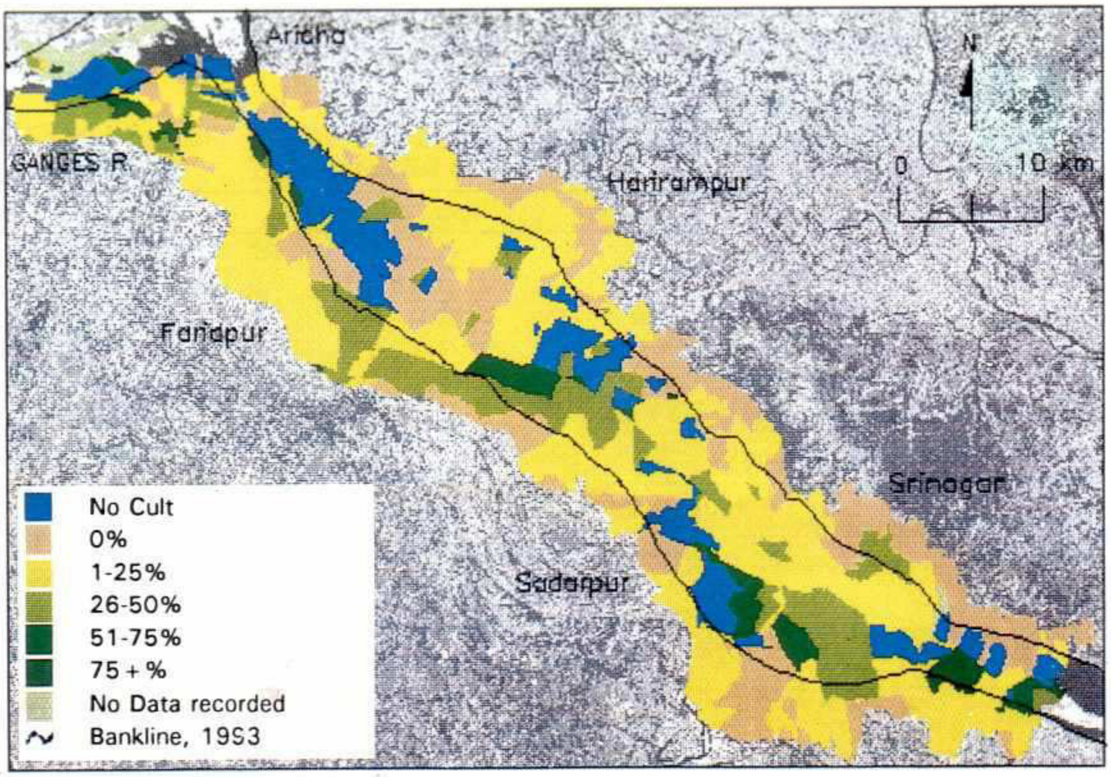

Figure 3.18

Source: ISPAN, 1993 Field data

Table 3.12 Rabi/Boro Cropping Pattern (percent of cultivable land under main crops)

Crop	Island Char	Attached Char	Unprotected Mainland	Upper	Middle	Lower	Total
Dry-land Crops	22	20	6	13	12	13	12
Wheat	4	18	14	19	15	7	13
Other Rabi Crops	28	31	35	26	37	31	33
L Boro	11	12	11	13	8	14	11
HYV Boro	2	2	14	6	8	13	9
Total	57	83	80	77	80	78	78

Source: Table B.33

unprotected mainland, particularly in the lower reach east bank (Figure 3.19), but Table 3.12 shows that local boro is widespread on all charland types, and presumably covers all suitable low-lying areas where there is residual moisture and soils are less sandy. The areas of dark green in Figure 3.19 highlight the sand-free areas of the east bank mainland of Srinagar where HYV boro is important (Table 3.12). Since HYV boro requires irrigation, the data imply that irrigation facilities are scarce in the Padma charlands. Despite this pattern of boro cultivation the island chars reported slightly higher yields for both types of boro than unprotected mainland mauzas (Table B.34), with lower yields in the attached chars.

Table 3.12 shows that the remaining rabi crops are the most widely grown winter crops in the study area. In addition to wheat, "other rabi crops" comprise pulses, chilies, potatoes, oilseeds (mainly mustard and *til*), and onions; there also are very small areas producing a wide range of other spices and vegetables. These crops are widespread but, when combined with wheat, are concentrated in the upper reach and west bank mainland (Figure 3.20 shows a reversal of the pattern in Figure 3.19). There are more sandy soils in the upper reach, but a wide range of crops, including wheat, seems to be preferred over crops most suited to these soils. Hence there is little difference in the intensity of rabi/boro cultivation between reaches, although the island chars are less intensively cultivated in the winter. The proportions of the various crops vary considerably between mauzas. The area under irrigated crops is still low, however, and in the island chars where river water is readily available it may be possible to increase coverage—provided the equipment used is portable (to cope with erosion and floods) and returns are sufficient.

An important constraint on some winter crops would appear to be the risk of early floods. Table 3.13 indicates that boro, potatoes, sweet potatoes, chilies, and millet (*kaon*) are all damaged on average at least once in 10 years by floods. This may account for the low percentages of land under

Table 3.13 Mean Number of Years in Ten with Flood Damage to Selected Crops*

Crop	Upper	Middle	Lower	Total
Kaon	1.5	1.2	0.0	1.2
Chilies	1.8	0.9	0.4	1.1
Potato	2.0	1.9	0.0	1.2
Sweet Potato	1.9	1.5	0.0	1.4
L Boro	2.9	0.9	0.2	1.2
HYV Boro	1.6	0.9	0.4	1.0
Aus	4.1	2.0	1.1	2.5
Jute	3.6	2.4	0.9	2.5
B Aman	4.5	3.2	1.9	3.2

Source: FAP 16 Inventory Survey

*Based on incidence of damage from 1988 through 1992. Other crops had a damage incidence of less than 1 in 10 years.

BORO CROP COVER

PROPORTION OF CULTIVABLE LAND UNDER BORO PADDY

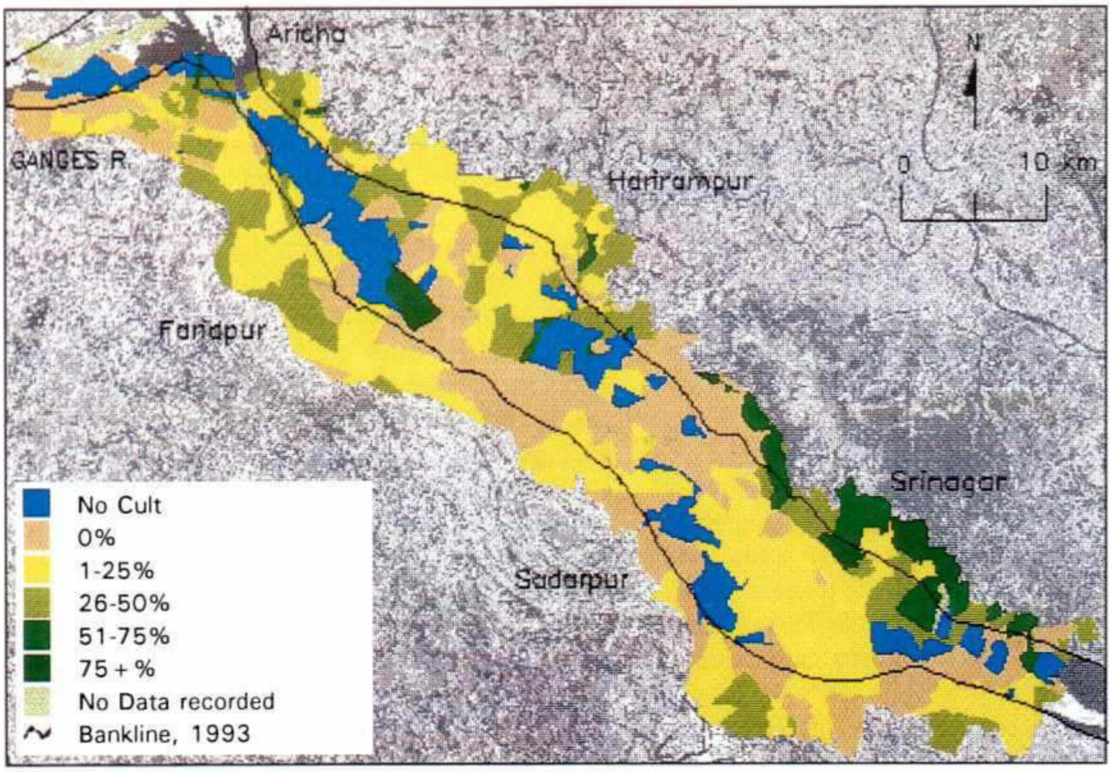

Figure 3.19

Source: ISPAN, 1993 Field data

RABI CROP COVER

PROPORTION OF CULTIVABLE LAND UNDER OTHER RABI SEASON CROPS

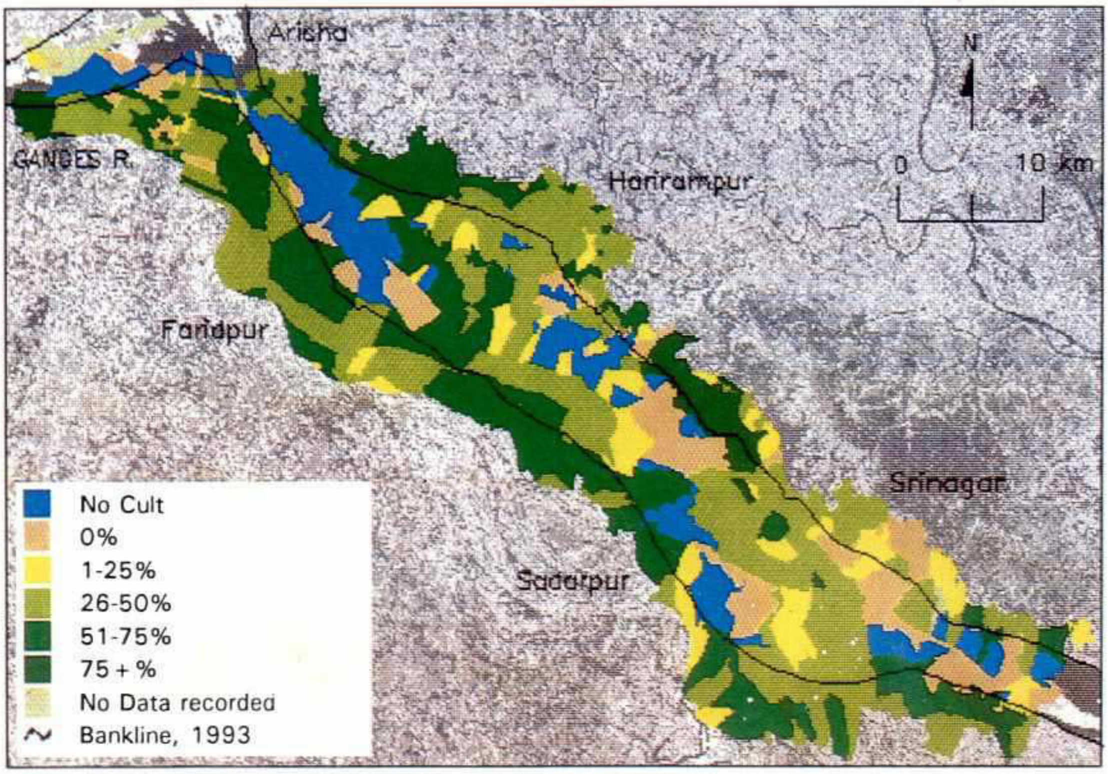

Figure 3.20

Source: ISPAN, 1993 Field data

some of these crops, particularly in the upper reach where the risks would appear to be much higher. For example, local boro has been damaged in the past five years (1988-92) which only include one severe flood year, and on this basis it can be expected to be damaged three years in 10. The sources of this flood damage are not known and deserve further investigation. In some mainland areas it could result from local rainfall congestion, but in most of the char area it must be due to early flood peaks affecting low-lying land. The upper reach has a relatively narrow channel and these flood peaks are presumably dissipated by the time they arrive in the lower reach.

Cultivation in the monsoon season is equally important as in the dry season but is dominated by just three crops. Of these, aus paddy is the most important and covers almost 50 percent of all cultivable land (Table 3.14) in the Padma charlands. Figure 3.21 shows that aus cultivation is widespread, and there is a slight tendency for the proportion of aus cultivation to increase from upstream to downstream. The lack of aus on east bank mainland in the lower reach reflects the local dominance of boro, the season for which overlaps that of aus. The general trend for more aus in the lower reach is probably linked to the risk of early floods in the upper reach, since the crop is particularly vulnerable to flood damages. Table 3.13 shows that the frequency of flood damage to aus is much higher in the upper reach (4-in-10 years) than in the lower reach (1-in-10 years).[4] Given the high risk (and the low yields; Table B.34) it is surprising that so much aus is grown in the upper Padma. Perhaps it is grown so extensively because it has low input requirements and it may be preferred on relatively light soils since late monsoon paddy (aman) might be affected by moisture stress.

Instead, Figure 3.22 shows the reverse, with the highest intensities of broadcast aman (B. aman) found in the upper and middle reaches. Many varieties of B. aman are tolerant of flooding and able to grow with rising water levels. Although B. aman is often mixed with aus, the survey did not distinguish this crop mix, but it appears that in the attached chars and unprotected mainland mixed aus and aman are most commonly grown. This may help to spread risks of flood damage, as aman may survive when aus is destroyed. Yet Table 3.13 shows that B. aman has been even more frequently damaged by floods in the past five years than aus. All monsoon season cultivation appears to carry a very high risk in the Padma area.

Jute, which is grown in the same season, is not a major crop in the area. Table 3.13 shows that in general aus and jute have been damaged with similar frequencies in the five years 1988-92, and can be expected to be damaged five years in 20.

Transplanted aman (T. aman) is higher yielding than broadcast varieties because it can be grown

Table 3.14 Monsoon Cropping Pattern (percent of cultivable land under main crops)

Crop	Island Char	Attached Char	Unprotected Mainland	Upper	Middle	Lower	Total
Aus	48	52	48	42	50	52	49
Jute	2	8	5	10	5	3	5
B. Aman	28	39	40	43	42	28	37
Total	78	99	93	95	97	83	91

Source: Table B.33

Note: Much of the aus and B. aman are broadcast together, but have been counted as separate crops because they are harvested at different times. Approximately 0.1 percent of land is under T. aman (in the attached chârs), no HYV aman is grown.

AUS CROP COVER

PROPORTION OF CULTIVABLE LAND UNDER AUS PADDY

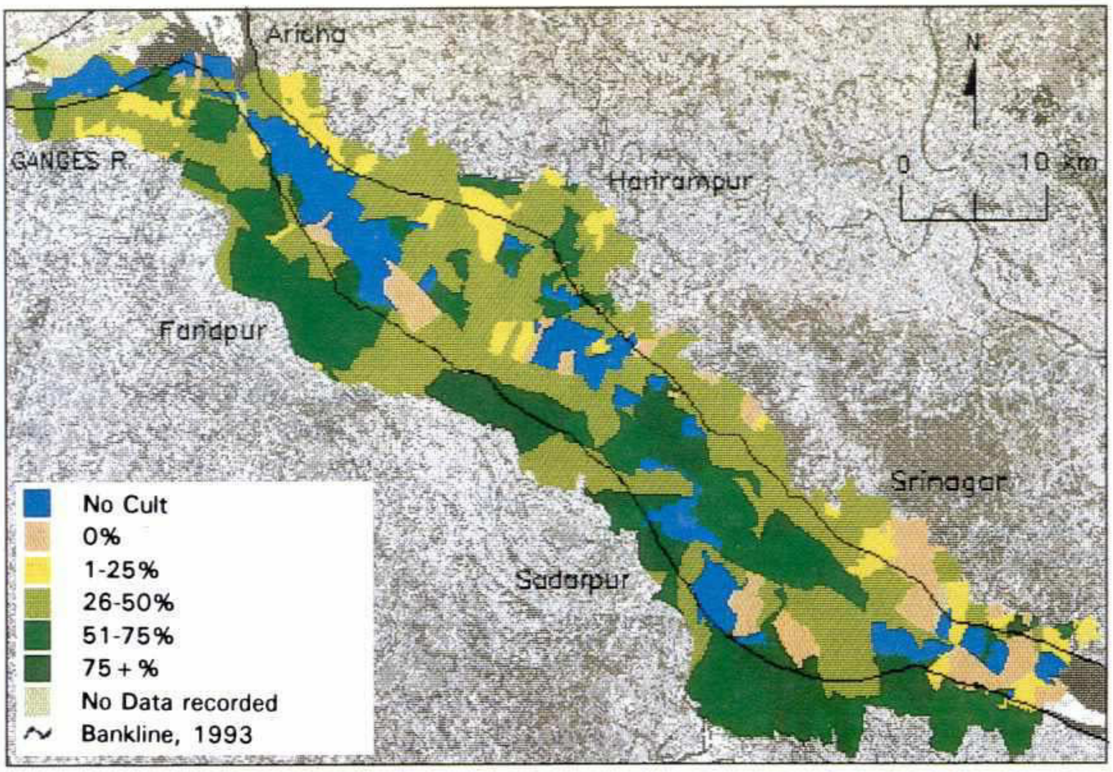

Figure 3.21

Source: ISPAN, 1993 Field data

B. AMAN CROP COVER

PROPORTION OF CULTIVABLE LAND UNDER BROADCAST AMAN PADDY

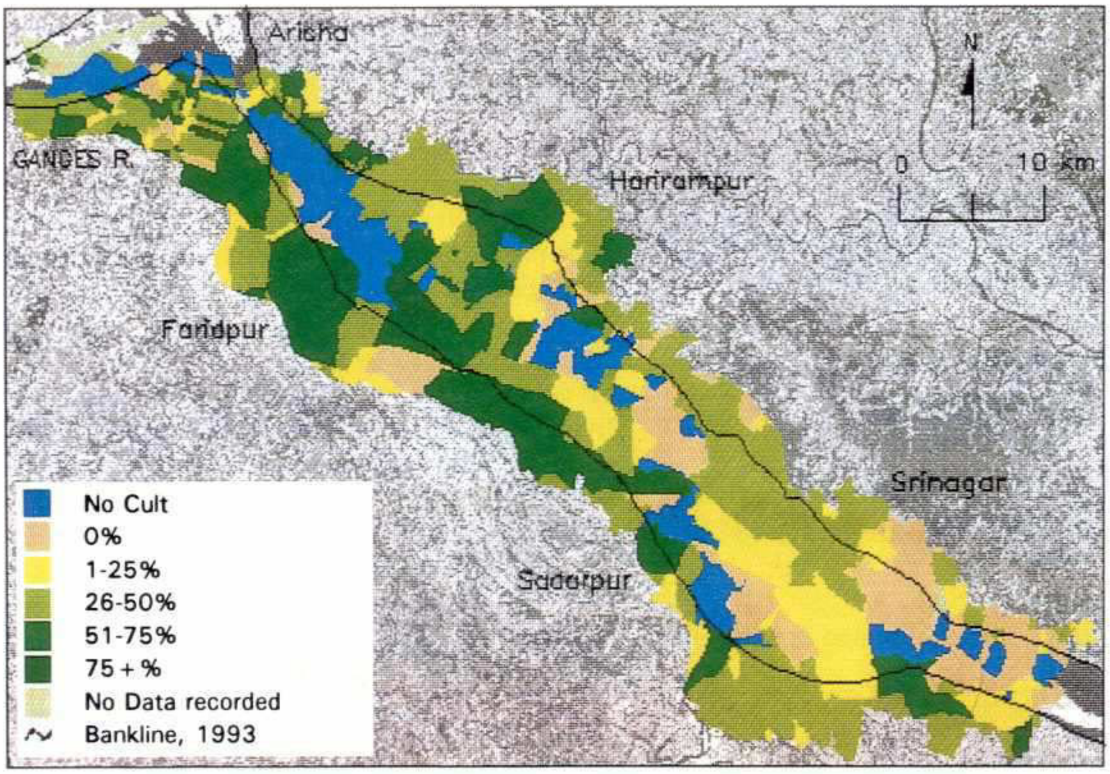

Figure 3.22

Source: ISPAN, 1993 Field data

under more controlled conditions and with more inputs, but it is shorter stemmed and more vulnerable to flood damage. As a result of the monsoon inundation regime and flood risk in the study area T. aman is virtually absent. No HYV aman was reported to be grown, and only a very small area of local transplanted aman was reported in the upper reach attached chars. This is in strong contrast with the Meghna charlands where T. aman is locally an important crop.

The inventory data on cropping systems suggest that deep flooding of the area is normal during monsoon season. A traditional system of mixed broadcast aus and aman is common in some areas, but the risks of flood damage are high even in years when there are no severe floods. This presumably reflects vulnerability of crops in the active floodplain and charlands to sudden increases in water levels. The area near Srinagar appears to have the main concentration of irrigation facilities and a single boro crop is common there. Monsoon water levels may rise too quickly and be too deep for B. aman paddy to be grown in this area after the harvest of boro. Aus is the most important crop by area, yet yields are low, it may be preferred over aman because of the combined risk of flood and drought in the late monsoon.

Although agriculture is quite intensive in the Padma chars, it is hazardous and could be more productive. For example, use of river water for irrigation in the char areas might enable aus to be replaced with boro giving higher yields and reducing the risk of flood damage. Farming system research in the Padma charlands would help farmers if incomes could be increased and made more stable. The available information indicates that the focus should start with the winter and early monsoon seasons.

3.5.3 Livestock

Livestock was divided into three categories: large (cattle and buffaloes), small (sheep and goats), and poultry. Data were collected to determine the mean number of animals per household and the number of animals per km^2 of non-flooded land during the dry season. The latter is an indicator of grazing land and fodder availability.

The number of cattle (there are few buffaloes in the study area) in the charlands changes somewhat between the dry and monsoon seasons (Tables B.36 and B.37). A total of just over 67,500 cattle and buffaloes were reported in the study area in the 1993 dry season, but there had been about 56,300 in the previous monsoon (83 percent of dry season number). This is consistent with the RRA in the middle reach which indicated that there was some seasonal livestock fattening but that this business was less widespread than in the Meghna charlands. For a short time after harvest groundnut plants are an additional source of fodder, and grasses are plentiful year-round, but must be cut and carried during the monsoon. In some areas green fodder is harvested in the chars and sold to mainlanders. The extent of normal monsoon flooding and the poverty of many char dwellers in this area may limit the opportunity to make use of fodder resources. The RRA found that in the island chars cattle were commonly raised on a share basis by tenant farmers. Through the remainder of this section the analysis relates to dry season numbers since these are compared with dry season land area and reflect the importance of livestock rearing in the area.

There were 87 animals per km^2 of dry season land (Tables B.38 and B.39) in the study area. High densities of large livestock are concentrated in the unprotected mainland, particularly the east bank (over 200 animals per km^2; pink and red in Figure 3.23). High livestock densities are associated with high population densities in this area, and with small mauzas where inventory estimates may be more accurate. These high concentrations of livestock may also be grazed in adjacent charlands or fed on grass cut from the chars. The high livestock density near Aricha is probably associated with cattle trading since it is on the main communication route from southwest Bangladesh to Dhaka.

Data on the number of large livestock per 100 households reveal that there are generally fewer

DENSITY OF LARGE LIVESTOCK TO LAND AREA

ANIMALS PER SQ. KM DRY SEASON LAND

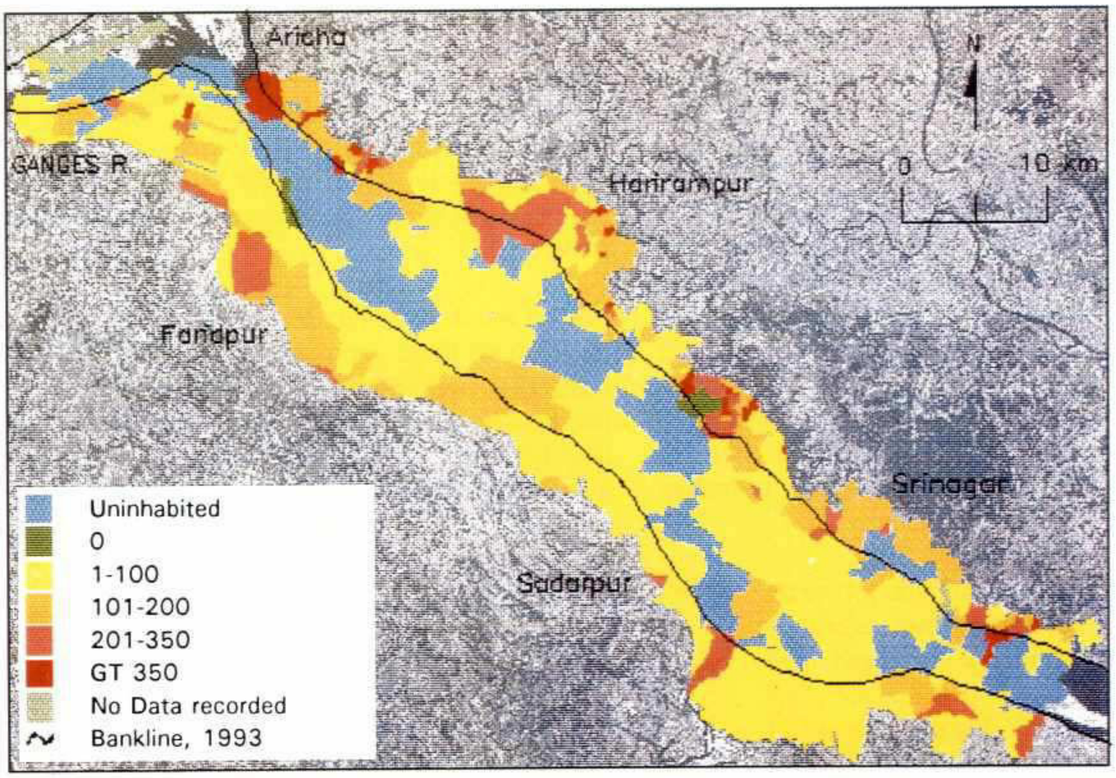

Figure 3.23

Source: ISPAN, 1993 Field data and Satellite image data

LARGE LIVESTOCK PER 100 HOUSEHOLDS

ANIMALS PER 100 HOUSEHOLDS

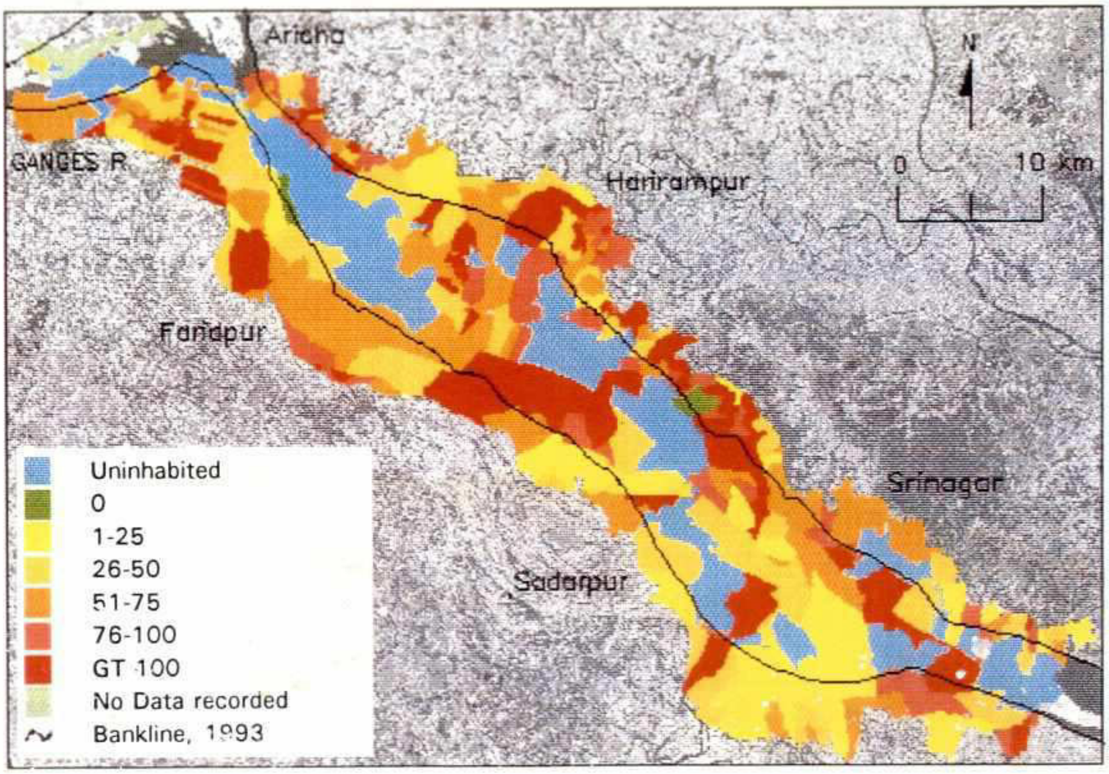

Figure 3.24

Source: ISPAN, 1993 Field data

than one animal per household (Figure 3.24; Tables 3.15 and B.40). Livestock ownership is lowest in the lower reach on the west bank (yellow in the figure). The inventory figures (0.6 cattle per household), however, are much lower than those reported during the RRA in the middle reach (about 2 cattle per household). This reach had the highest ownership in the inventory, averaging 0.9 cattle per household, but this still implies that the inventory under-recorded cattle. Cattle ownership is high (red) in both stable unprotected mainland and on some of the island chars in the middle reach, and locally in the other reaches. The number of large livestock per household appears to be less than the national average, even in the dry season when there are favorable fodder resources (Table 3.15).

In the mainland areas refuges for cattle (embankments or roads) are relatively close and accessible by land, but high land is scarce or absent in the island chars (middle reach RRA). Despite the use of catkin grass to make raised platforms for cattle, the need to evacuate livestock to embankments on the mainland and the cost of transport by boat were reported to be problems in the 1988 flood. Local assessment of arrangements for safeguarding livestock in floods, of seasonal livestock numbers, and distributions is needed for planning cattle shelters in the Padma charlands. Such measures might be beneficial in the middle reach and some villages in the lower reach, but the risk of erosion in these island chars appears to be high.

The distribution of sheep, goats, and other small stock is similar to that of large livestock. Tables B.41, B.42, and B.43 show a marked upstream-downstream trend in small stock relative to dry season land area: 127 per km^2 in the upper reach, 93 per km^2 in the middle reach, and 55 per km^2 in the lower reach. Figure 3.25 shows that the concentrations of small stock (more than 200 per km^2, colored pink and red) are in the unprotected mainland and attached chars of the upper reach. Although these areas also had the highest population densities in 1993, Table B.43 shows that small stock ownership showed the same upstream-downstream trend: 0.9 animals per household in the upper reach, 0.7 per household in the middle reach, and 0.4 in the lower reach. Yet none of these averages are higher than the national average. Grazing resources appear to be particularly under used in the lower reach, where there are few small stock.

Poultry numbers in the area are reported to be just under three birds per household, lower than the national average (Table 3.15). Poultry ownership per household averages almost the same on all land types, but is slightly higher (3.3 per household) in the middle reach (orange and pink in Figure 3.26). As with other livestock, ownership is lowest in the lower reach (Tables B.44 and B.45).

Table 3.15 Livestock Ownership Per Household

Land Category	Large Livestock	Small Livestock	Poultry
Island Chars	0.67	0.70	2.92
Attached Chars	0.64	0.73	2.92
Unprotected Mainland	0.60	0.57	3.02
Charland Average	0.61	0.61	2.99
Bangladesh Average†	1.33	0.96	4.99

†Based on 1983/4 Agriculture and Livestock Census and 1981 Population Census.

DENSITY OF SMALL LIVESTOCK TO LAND AREA

ANIMALS PER SQ. KM DRY SEASON LAND

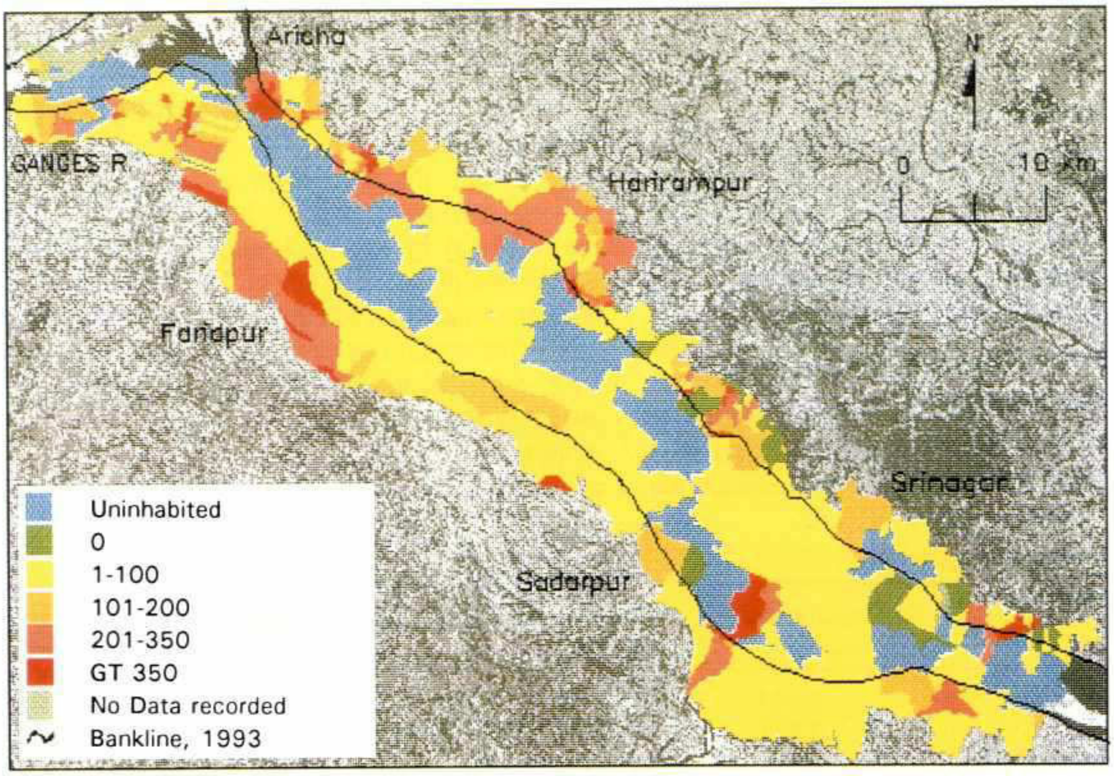

Figure 3.25

Source: ISPAN, 1993 Field data and Satellite image data

NUMBERS OF POULTRY PER HOUSEHOLD

POULTRY PER HOUSEHOLD

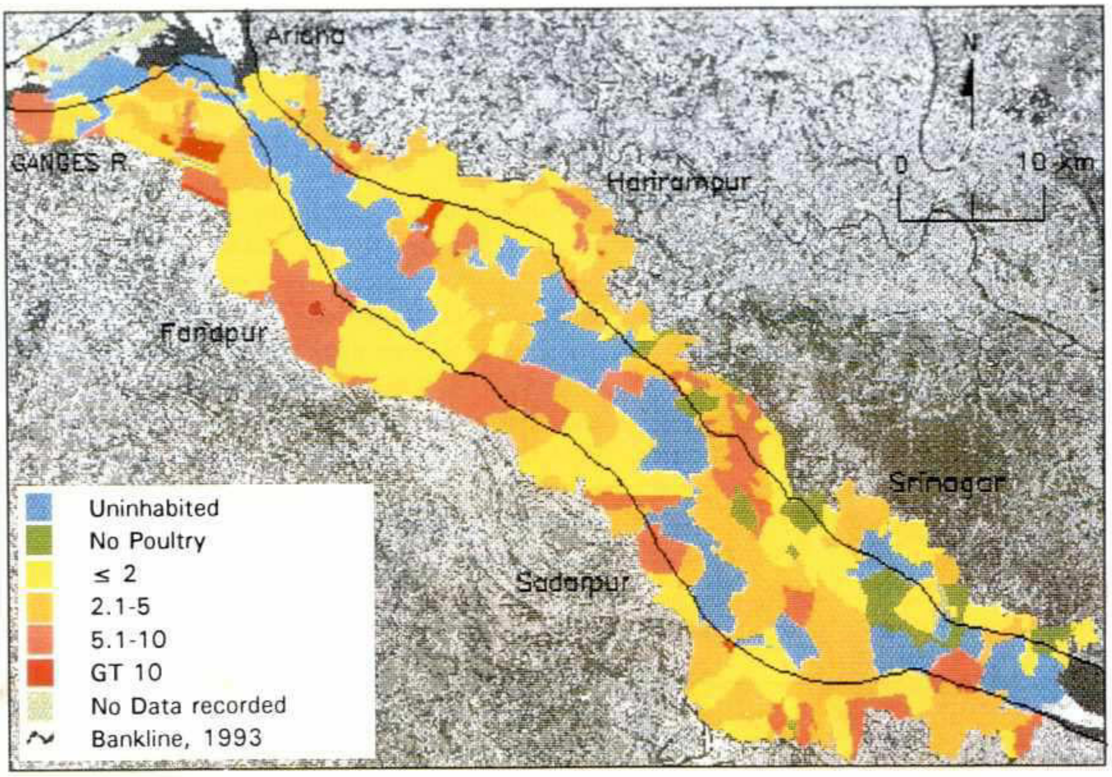

Figure 3.26

Source: ISPAN, 1993 Field data

3.5.4 Boat Availability

Small, non-mechanized boats are a vital household resource in the char areas, both as a means of transport in the monsoon and a means of saving life and property in severe floods. FAP 14 found that 26 percent of households in a sample of char villages took shelter on boats during a severe flood (FAP 14, 1992). Figure 3.27 shows that, although it is rare for every household in a mauza to own a boat, there is a high level of boat ownership in the Padma study area. The highest ownership levels (red and dark red) are concentrated along the main channel and in the nearby attached chars. As noted in Section 1.3.2 some of the west bank attached chars are separated from the true mainland by secondary channels which join the Padma, so boats are as important for communications in these areas as in the island chars within the main channel.

Non-mechanized boats include "country boats", which operate as commercial cargo carriers, but the majority in this category are small boats for household use. It is possible that the number of the smallest boats, dinghies, has been underestimated in this survey. The study survey found that there are nine households per non-mechanized boat (Table 3.16). Boat ownership is highest in the middle reach (7 households per boat) and lowest in the lower reach (15 households per boat). Lower reach unprotected mainland has by far the lowest boat ownership, averaging 28 households per boat (Tables B.46 and B.47).

Although boats are a source of employment for very few of the study area households, since the late 1980s mechanized boats have become increasingly important as a means of transport in riverine areas, including the Padma (Charland Study RRA surveys). Large country boats without engines were important in the Padma in earlier years, and were used to move homes and property when erosion and flooding occurred in 1988 (RRA surveys). Mechanized boats have helped improve the reliability of communications to marketplaces and the mainland, and they are the main means of speedy evacuation of people, livestock, and property when erosion or severe floods strike. Figure 3.28 shows that mechanized boats are widely available along the main river channel. There are more mechanized boats on island chars than other areas (32 households per boat; Table 3.16), and more in the lower reach where there are only 64 households per boat on average. These areas show mainly red in Figure 3.28. The lowest ownership is in the mainland in the upper reach on both banks (Tables B.48 and B.49) where there are an average of more than 400 households per boat.

For the most part, then, the island and attached chars, which have the greatest need to evacuate by boat, should not face a shortage of boats (mauzas without mechanized boats are yellow in Figure 3.28). Along most of the river local mechanized boats now have the potential to provide transport and evacuation services during severe floods, especially if these privately owned boats can be contracted by local government to assist the poorest households, which may be unable to afford to evacuate, as well as to carry medical and relief services and supplies.

Table 3.16 Boat Availability

Land Category	Non-mechanized Boats (no.)	Households Per Non-mechanized Boat	Mechanized Boats (no.)	Households Per Mechanized Boat
Island Char	2,190	5	338	32
Attached Char	2,828	7	386	49
Unprotected Mainland	6,869	12	549	148
Total	11,887	9	1,273	87

Source: Tables B.46 to B.49

HOUSEHOLDS PER NON-MECHANIZED BOAT

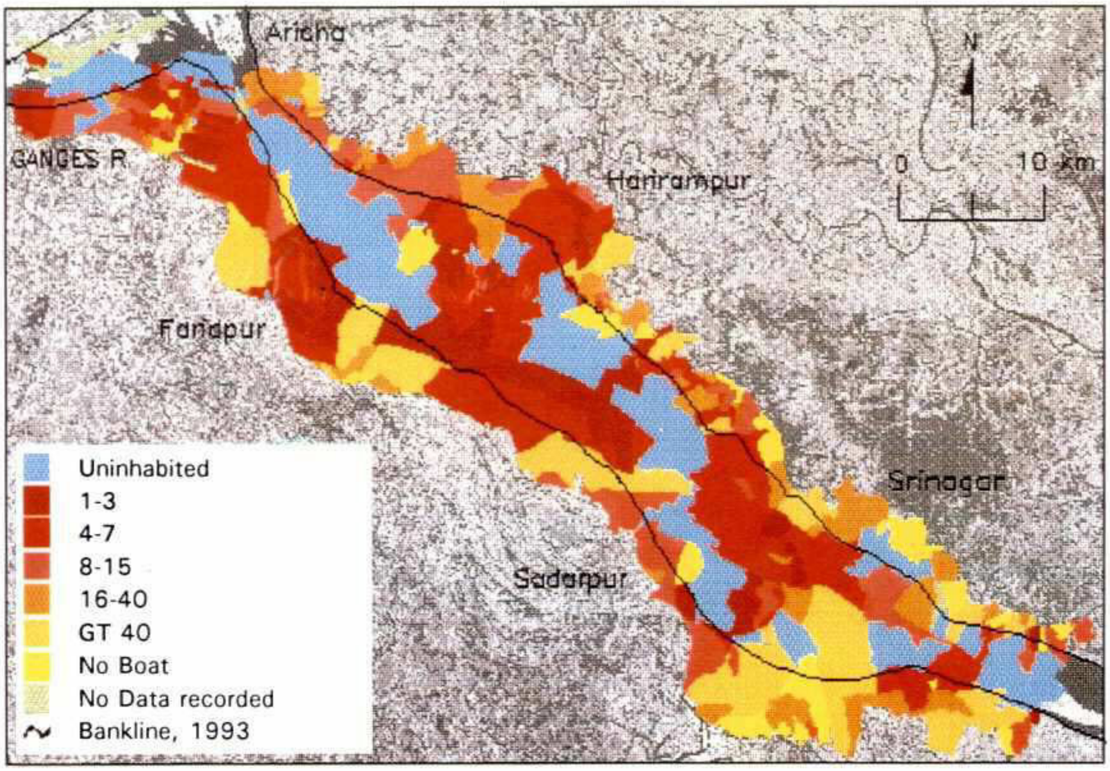

Figure 3.27

Source: ISPAN, 1993 Field data

HOUSEHOLDS PER MECHANIZED BOAT

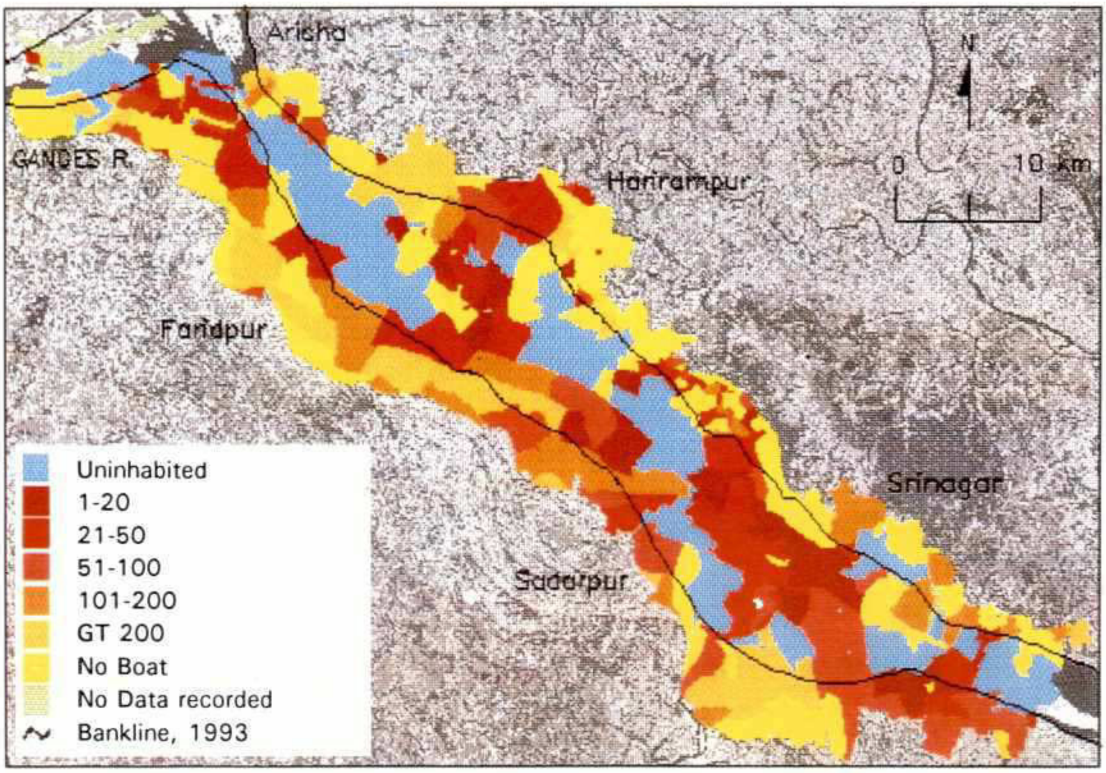

Figure 3.28

Source: ISPAN, 1993 Field data

3.5.5 Social Conflict

The dynamism of charlands, where the chief economic resource—land—is constantly changing under the influence of erosion and accretion, brings with it the potential for considerable social friction. Past studies of charlands in the Jamuna and Lower Meghna areas have found the combination of changes in land and movements of people to be a potent source of social conflict (Elahi *et al.*, 1991; Adnan, 1976; Zaman, 1989).

Although people may be unwilling to discuss land disputes, questions about disputes over allocation of newly accreted or re-emerged land were included in the inventory (for example, cases where a local court (*salish*) was involved). The inventory found that 62 percent of inhabited mauzas had experienced such land disputes, although in most cases there have been fewer than one a year.

Disputes were concentrated in the upper and middle reaches (76 and 71 percent of mauzas, respectively, compared with only 36 percent in the lower reach; Table B.35). Bank erosion has been concentrated in the lower reach, but there has also been considerable accretion of new land during the period 1984-93 (Chapter 2) which is likely to have resulted in more disputes. Still, 50 percent of mauzas with land disputes in this reach were in the island chars. Overall 84 percent of island char mauzas reported disputes over accreted land, compared with 56 percent of unprotected mainland mauzas (Table 3.17). Disputes do not correlate with population pressure; the highest population densities are in the mainland. A high percentage of disputes involved violence (60 percent of mauzas with disputes), but deaths related to land disputes occurred in few mauzas.[5]

Table 3.17 compares the severity of disputes between char land types. The island chars have clearly experienced disputes in more mauzas, and more than 50 percent of these mauzas have been the scene of violent disputes. The middle reach RRA found that people frequently move as land erodes and accretes. Many people on island chars in the Padma live as tenants of absentee landowners, and the land in some of the island chars is reported to be controlled by a few landlords. These problems can be expected to continue, since there is no reason to believe that the river morphology has stabilized (see Chapter 2).

Where land has submerged and later accreted, disputes often arise about the demarcation of land and peoples' rights to it based on prior claims. These claims are usually managed through informal land allocation mechanisms that circumvent having the land claimed as *khas* land by the government. When land accretes in a new area where there are no prior claims (or anyone to assert prior claim) land grabbing and pressure among erosion victims to secure access to land as tenants of local landlords and patrons triggers disputes and social conflict. Further study would be needed to establish the present extent of these problems. Development programs or flood proofing measures for the Padma charlands would need to be carefully planned to avoid being undermined by such conflicts and to take account of the existing power structure.

Land disputes often arise where mauza boundaries are unclear, and even where thana and district boundaries meet, so the extent to which char people have access to the local power structure and administration may be important.

Table 3.17 Percentage of Mauzas Reporting Land Disputes*

Type of Dispute	Island Char	Attached Char	Unprotected Mainland	Study Area
Any Dispute	84	63	56	62
Outsider Involvement	40	32	28	31
Violence	56	37	32	38
Deaths	7	5	5	5
Inhabited Mauzas	55	62	195	312

Source: FAP 16 inventory
*Information covers recent years.

27

HAZARDS

3.6 Hazards

3.6.1 Health Hazards and Loss of Life

Disease, in epidemic form, has been the main cause of human death among the hazards surveyed. Averaged over five years the incidence of epidemic deaths every year is 63 per 100,000 people, 71 percent higher than the incidence of deaths in the 1988 flood (37 per 100,000 people). Informants were asked for the number of deaths from a variety of hazards in the past five years. The predominant hazards resulting in death are mapped in Figure 3.29. They include: the 1988 flood, epidemic disease since 1988, tornados/cyclones, and "famine." The causes of death shown in Figure 3.29 exclude deaths by natural causes and are based on the period 1988-92, or part of that period if the mauza was only inhabited for part of the time. The "other" category includes the few deaths attributed to erosion, although those may be difficult to separate from flood deaths. Cyclones and tornados appear to kill few people, and have been significant only in a few scattered mauzas. Floods since 1988 were not reported to have caused any deaths in the Padma charlands, despite the frequent crop damage reported in Section 3.5.2. The few mauzas where famine was reported may have referred to food shortages in 1988. It is notable that no hazard-related deaths were reported from most of the lower reach island chars (yellow in Figure 3.29).

The number of deaths attributed to the 1988 flood are shown separately in Figure 3.30[6]. Those 221 deaths were concentrated in the upper reach on the west bank and on the island chars and east bank mainland of the middle reach (Figure 3.30; Table B.50). There were virtually no inhabited island chars in the upper reach in 1988, so the chance there were any deaths there was very low. Otherwise the pattern is consistent with the information on flood extent and impacts in Sections 3.6.2 and 3.6.3 which show that the lower reach was less badly affected by the 1988 flood. Relative to the 1993 population (since the 1988 population is unknown), the reported death rate was highest in the upper reach: 92 deaths per 100,000 people (Table B.51). By comparison, the middle reach reported 35 deaths per 100,000 and the lower reach, 9 deaths per 100,000. Figure 3.30 indicates a concentration of mauzas in the upper reach (orange and red) where improvements in flood warning and response, including flood shelters, might have saved lives. Such measures might also have benefitted people in the middle reach island chars. Detailed local study is needed to discover the reasons for these deaths and whether such measures are needed now.

Deaths reported from epidemic outbreaks of disease have been much more widespread than deaths by flooding, but with the highest incidence in the west bank of the upper and middle reach and in middle reach island chars (Figure 3.29; Tables B.52 and B.53). These are the same areas which reported most flood deaths in 1988. Since Section 3.4.2 showed that health care facilities are no less available here than in the rest of the Padma charlands, so inadequate health care services are unlikely to be the explanation for most of this area. Since diarrhoeal diseases are often associated with severe floods and Section 3.4.3 showed that most people were forced to drink river/flood water during the 1988 flood, there may have been epidemic outbreaks of disease in this area following the flood. Coupled with problems of access from the island chars to mainland health facilities, this could explain the high average death rate of just over 100 deaths per 100,000 people per year in the island chars.

These hazard-related deaths are only a fraction of the overall death rate from natural causes and hazards. The crude death rate in 1991 was 11.5 deaths per 1,000 people in rural areas (BBS, 1993).

Given the above findings, the number of lives that can be saved by improving basic health care, especially access to emergency health care for the island chars, is likely to be greater than can be achieved by providing flood shelters. One component of flood-time health protection must be to prevent the widespread ill effects of drinking river water (see Section 3.4.3).

HUMAN DEATHS BY PREDOMINANT HAZARD TYPE

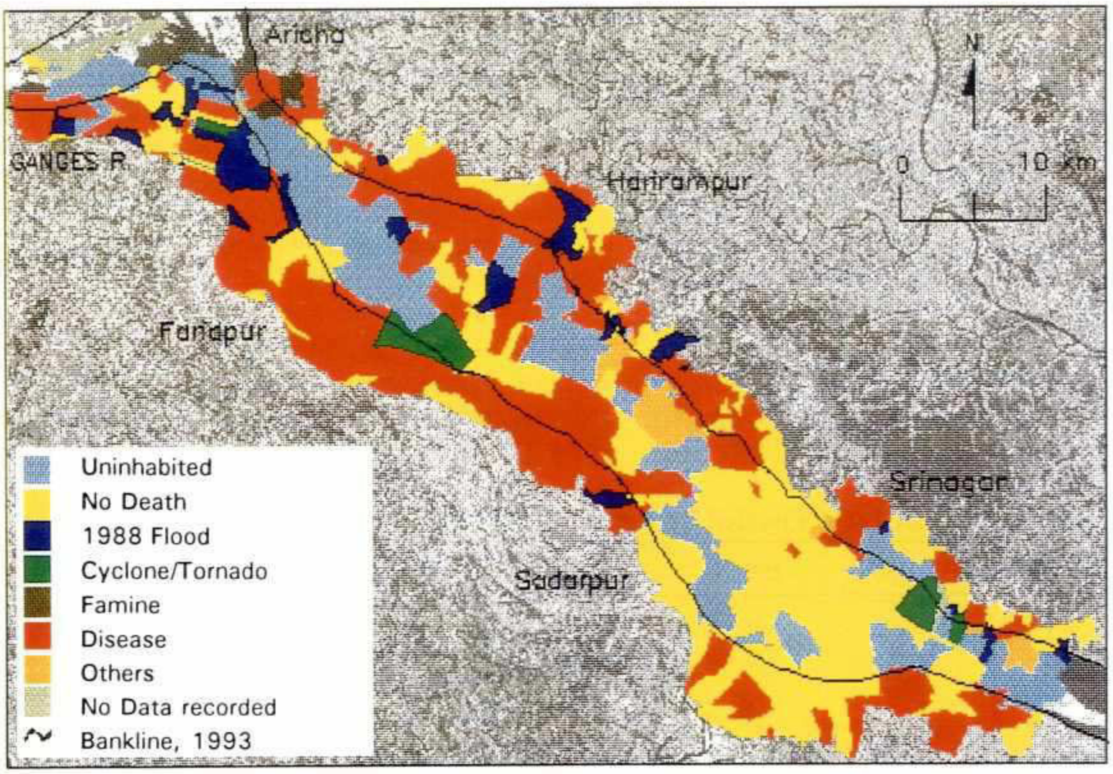

Figure 3.29

Source: ISPAN, 1993 Field data

DEATHS DUE TO 1988 FLOODING

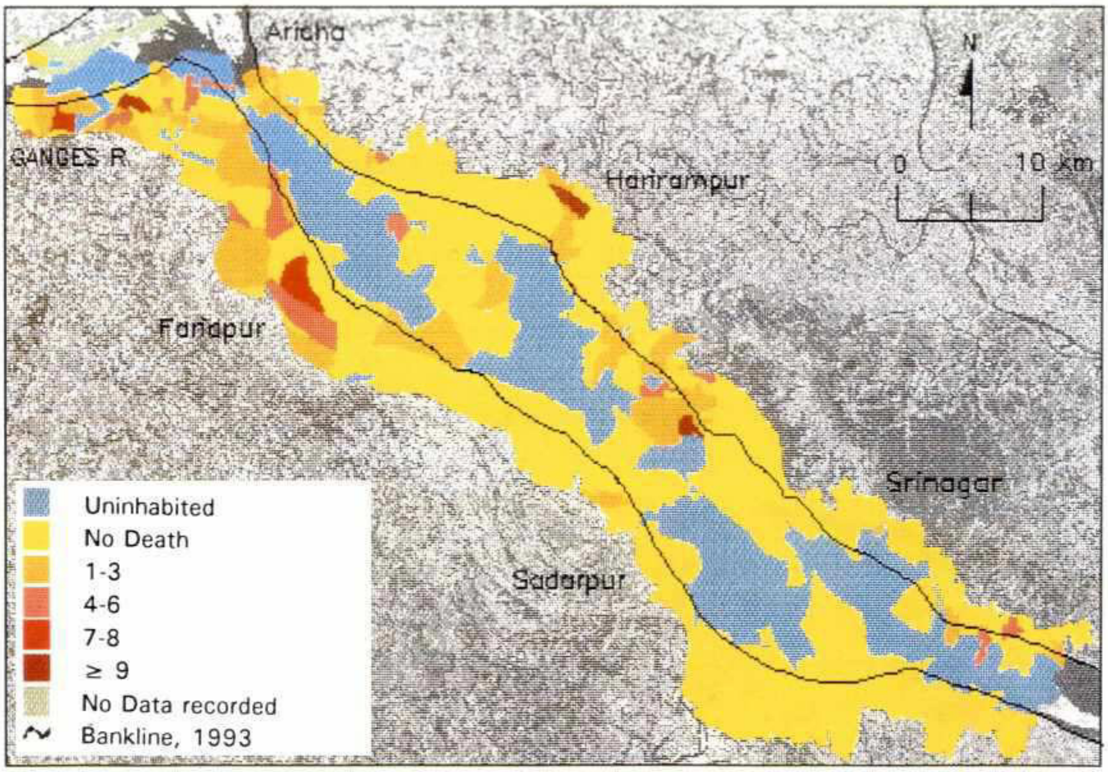

Figure 3.30

Source: ISPAN, 1993 Field data

3.6.2 Recent Flood Experience

Estimates of flood extent and duration were collected in each mauza for each year from 1987 to 1992, which spans two high flood years (1987 and 1988), three "normal" years (1989-91), and a low flow year (1992). Knowing the extent of flooding, it is possible to estimate the population that may have been affected by these floods. It also allows quantification of the normal extent of monsoon inundation and its influence on agriculture. Flooding duration is equally important in assessing the severity of the event, since it indicates the length of time that people may be marooned on, or evacuated to, embankments and higher land.

Table 3.18 Percentage of Land Flooded by Reach

Reach	1987	1988	1991	1989-92*
Upper	71	100	46	45
Middle	81	100	71	71
Lower	58	100	55	56
Total	71	100	61	60

Source: Tables B.54, B.56, B.58, B.60
*Mean percentage for four years

In order to standardize the inventory estimates key informants were asked to estimate the percentage of cultivable land under water at the peak water level in each year, and the number of days that land was underwater. Estimates of flood duration are probably more variable than those for extent, due to differences in interpretation between informants, but they are intended to show the number of days the mapped flooding extent lasted. In some mauzas informants apparently could not estimate flooding duration, probably because variations in land level created an uneven duration pattern (such mauzas with missing data are colored pale brown in maps of flood-related data). Separate estimates were made of the incidence of homestead flooding (Section 3.6.3).

The number of uninhabited mauzas (pale blue) changes from year to year. For example, more mauzas were uninhabited in 1987 and 1988 than in 1993. Since the absence of people generally correlates with submergence, these mauzas were already underwater during the flood season in the relevant years and therefore do not figure in the flooding data. The averages mapped for 1989-92 are the average for up to four years, thus, if a mauza was last settled in 1990 then the average is for three years (1990-92).

Figure 3.31 shows that in 1987 the most extensively flooded areas were in the upper and middle reaches, particularly on the east bank and island chars (85 percent or more flooded on average; Table B.54). Overall in that year, 71 percent of cultivable land was underwater, but in the lower reach even island char mauzas were less affected (56 percent flooded). Table 3.18 shows that the mean percentage of flooded land was highest in the middle reach. In the lower reach east bank land appears to have either been completely flooded (dark blue) or not flooded (yellow). Roads in this area, although not designed as flood embankments, may have been effective in excluding flooding from some mauzas in 1987. In contrast, on the west bank there is a flood protection embankment which forms the study area boundary, and the figure indicates that the land up to this boundary was flooded.

Duration of flooding in 1987 follows a similar pattern. Figure 3.32 shows that mauzas where the

Table 3.19 Duration of Flood by Reach (days)

Reach	1987	1988	1991	1989-92*
Upper	28	42	19	18
Middle	33	37	32	31
Lower	27	44	27	32
Total	30	40	27	28

Source: Tables B.55, B.57, B.59, B.61
*Mean duration for four years 1989-92

PEAK FLOOD EXTENT 1987

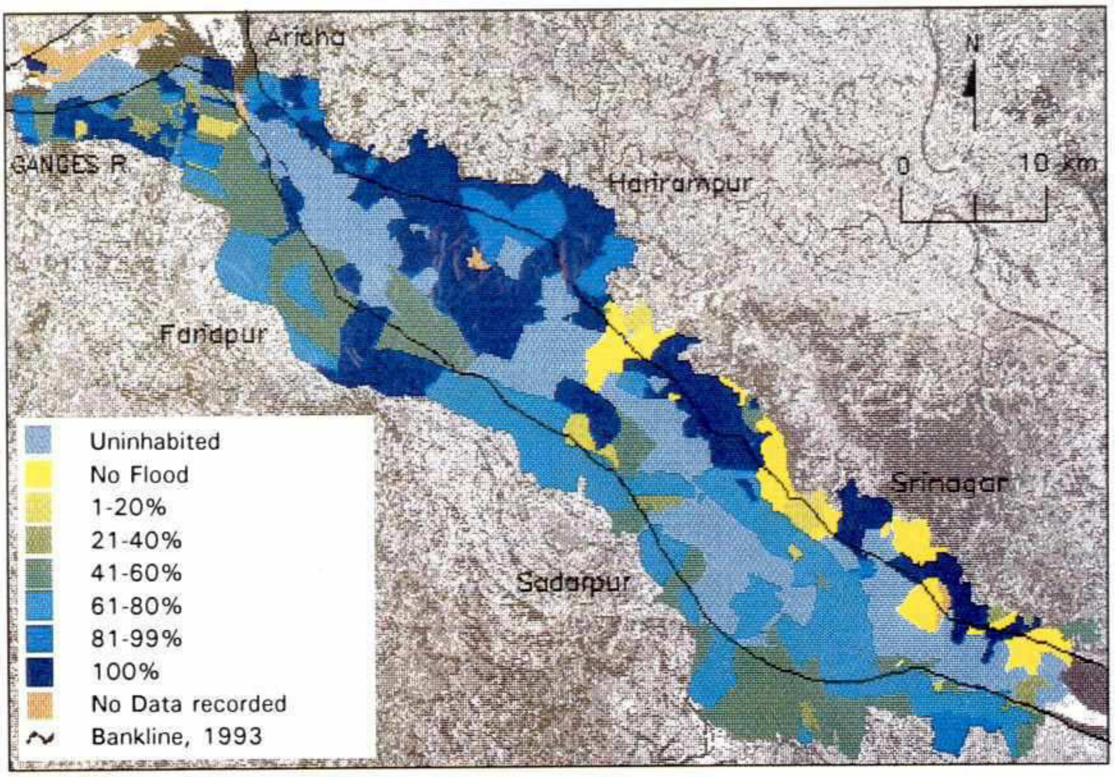

Figure 3.31

Source: ISPAN, 1993 Field data

PEAK FLOOD DURATION 1987

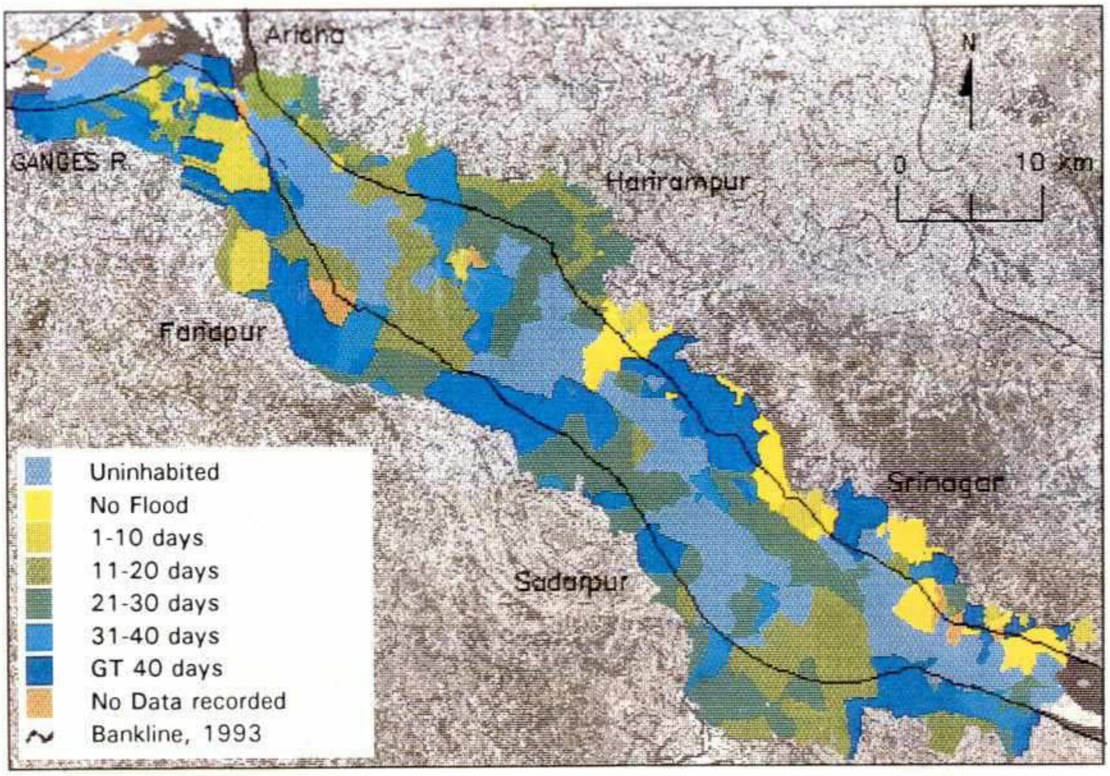

Figure 3.32

Source: ISPAN, 1993 Field data

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Table 3.20 Percentage of Land Flooded by Char Type

Char Type	1987	1988	1991	1989-92*
Island Char	73	100	72	72
Attached Char	65	100	47	47
Unprotected Mainland	73	100	62	61
Total	71	100	61	60

Source: Tables B.54, B.56, B.58, B.60
*Mean percentage for four years 1989-92

flood lasted more than 40 days (dark blue) are concentrated along both banks in the middle reach, and are scattered along the west bank of the other two reaches. Island chars averaged slightly shorter floods than attached chars and mainland (Table B.55). Average durations were little different between reaches or char types in 1987 (Table 3.19), and flooding lasted about one month on average, but east bank unprotected mainland averaged three weeks because of the higher proportion of mauzas which were not flooded. These durations are much lower than those reported for the Upper Meghna and about 10 days longer than in the Padma-Meghna confluence.

Figure 3.33 and Table 3.20 show that all cultivable land in the study area was flooded in 1988. Therefore, local flood protection and barriers within the east bank active floodplain (the possible reason for flood-free areas in 1987) were not effective in 1988. This is consistent with 1988 being a much more severe flood, and confirms that flood damage to monsoon crops in the lower reach occurred in 1988, making the minimum frequency of crop damage one year in the period 1988-92.

Figure 3.34 shows that flood durations were longer in 1988 than in 1987. The pattern shown in Table 3.19 is the reverse of that in 1987 with slightly longer flood durations in the upper and lower reaches. Flooding lasted an average of 10 days longer (40 days), but there was no consistent trend for land types between reaches (Tables B.57 and 3.21). Figure 3.34 does show that the west bank tended to be flooded longer, averaging between 46 and 49 days compared with 33 to 39 days on the east bank (attached chars and unprotected mainland). The reasons for this are unclear, and may deserve investigation; presumably either drainage is more impeded or the land on the west bank is lower than on the east.

The RRA found that key informants in the middle reach chars considered 1991 to have been a flood year. Flood extent for the whole study area that year averaged 61 percent of cultivable land, but Table 3.18 shows that the middle reach had the worst flooding; 88 percent of island char land there was flooded (Table B.58). The upper reach was least affected in 1991; only 65 percent of the area flooded in 1987 was affected.

Flood duration in 1991 was only 10 percent shorter than in 1987, but 32 percent shorter than in 1988 (Tables 3.20 and B.59). Durations were reportedly the same in the middle and lower reaches in 1987 and 1991, but in the upper reach flooding lasted less than three weeks. These results are consistent with the estimated return periods of flood levels in 1991 (see below), which indicate more extreme flooding in the lower reach.

Table 3.21 Duration of Flood by Char Type (days)

Char Type	1987	1988	1991	1989-92*
Island Char	28	41	28	33
Attached Char	31	46	24	24
Unprotected Mainland	31	39	28	27
Total	30	40	27	28

Source: Tables B.55, B.57, B.59, B.61
*Mean duration for four years 1989-92

PEAK FLOOD EXTENT 1988

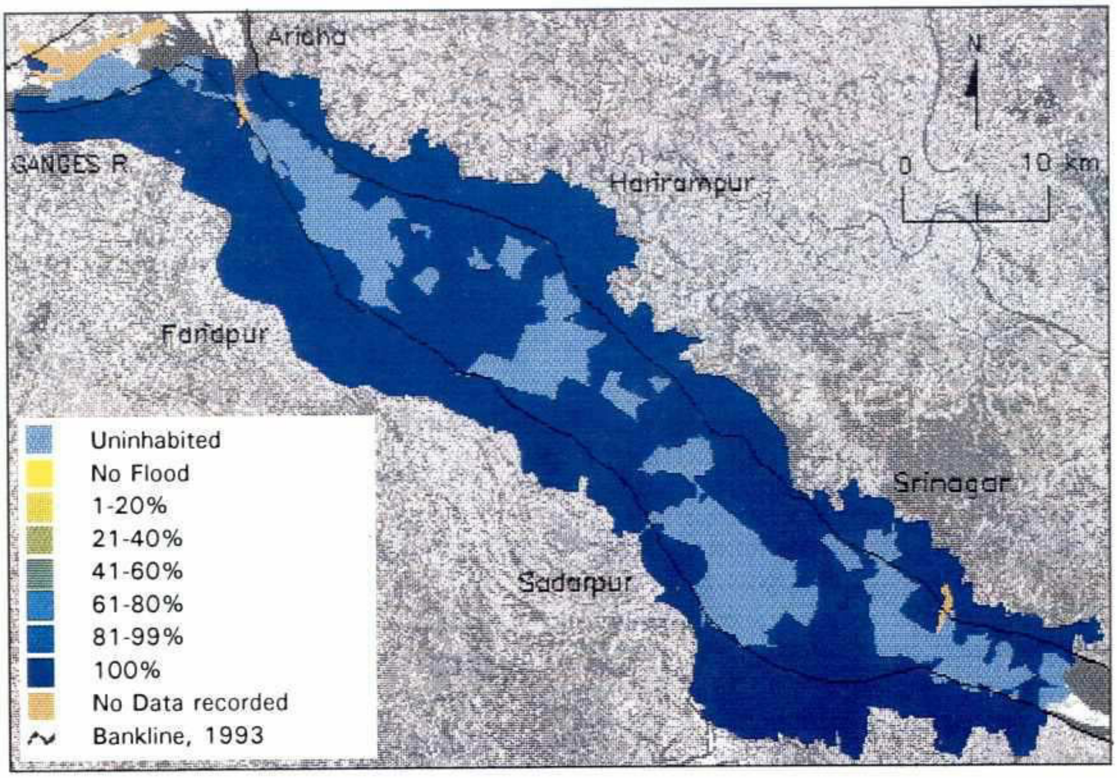

Figure 3.33

Source: ISPAN, 1993 Field data

PEAK FLOOD DURATION 1988

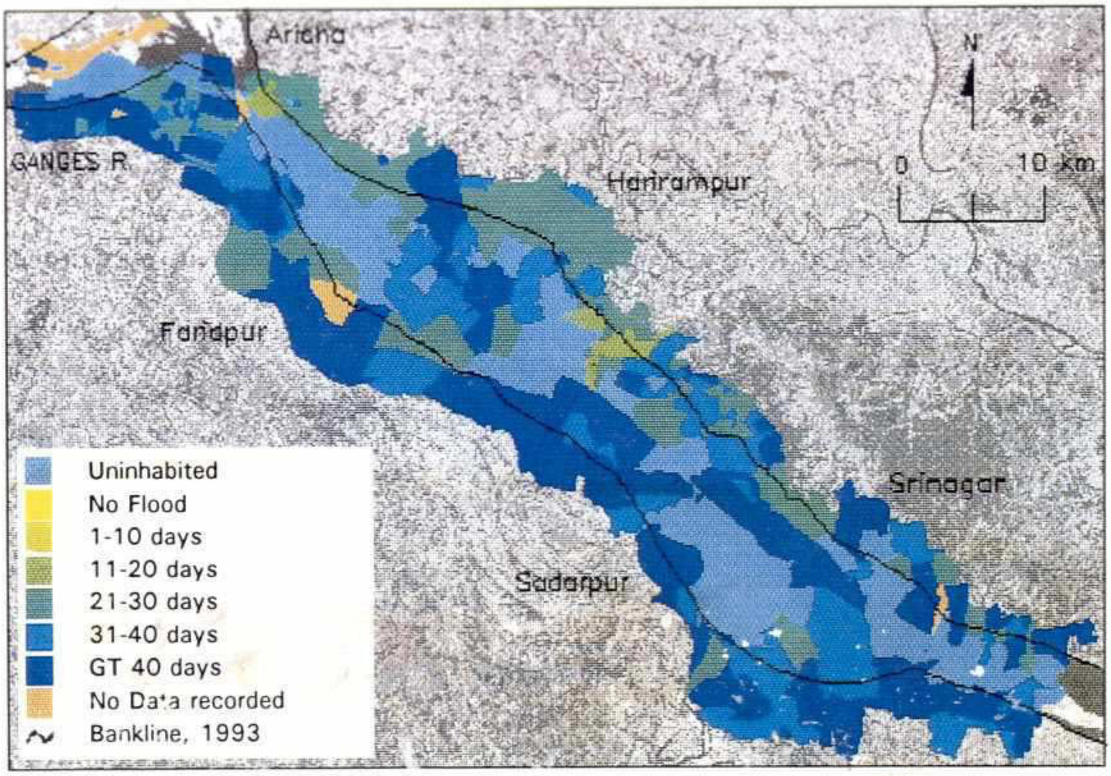

Figure 3.34

Source: ISPAN, 1993 Field data

Average flood extent and duration for the four years 1989 to 1992 are typical of normal monsoon conditions, since these were not severe or unusual flood years for the Padma (Table 3.22). Extensive flooding of cultivable land is normal in the island chars and east bank mainland, particularly in the upper and middle reaches (dark blue in Figure 3.35). Consequently attached charland, which is concentrated on the west bank, is normally least flooded (47 percent of area flooded; Tables 3.20 and B.60). Figure 3.35 shows a similar pattern of nonflooded mauzas in the lower east bank during 1989-92 as in 1987, which is thought to be due to local topography and roads. Tables 3.18 through 3.21 show that average 1989-92 flood conditions were almost identical to those in 1991. Thus, Figure 3.36 shows longer flood durations (darker blue) concentrated in the middle reach, which correlates with more extensive flooding and, therefore, more low-lying land.

Table 3.22 Return Periods of Padma Floods

Year	Baruria*		Mawa*	
	Level (m)	RP† (years)	Level (m)	RP (years)
1987	9.04	22.55	na	na
1988	9.35	54.44	7.06	58.01
1989	7.74	1.07	5.69	1.19
1990	8.49	4.70	5.87	1.79
1991	8.27	2.70	6.26	6.00

Source: 1987-89 FAP 25 (1992) Appendix 6; 1990 and 1991 FAP 25 unpublished data derived from BWDB gauging stations.

*Gauging stations in the upper and lower reaches, respectively.

†RP = Return Period; 22.55, for example, indicates a flood that occurs about once every 22 years. Return periods for 1990 and 1991 are estimated from probability plots in FAP 25 (1992).

Normal monsoon floods last for about a month in the middle and lower reaches, but for only 18 days in most of the upper reach. Flood water may back up in the middle and lower Padma reaches because of the narrow channel at the downstream end of the lower reach and high water levels in the Meghna.

The 1989-92 flood averages are benchmarks against which to assess the severity of the 1987 and 1988 floods. In normal conditions, 60 percent of cultivable land in the study area is under water in the monsoon, but 11 percent more cultivable land was flooded at peak level in 1987, and in 1988 the remaining land was flooded (all land flooded). More land was flooded than normal in the attached chars in 1987, and in the upper reach an extra 26 percent of land was affected over the 1989-92 area. The middle reach, then, is normally extensively flooded, but in a moderate-to-severe flood (1987) the upper reach is harder hit, and in 1988 the whole Padma charlands were flooded for more than five weeks.

In 1987, only the upper reach attached chars and unprotected mainland had flood duration that was longer than normal (by 56 percent). In 1988, flood durations increased by about 10 days over normal durations in all land types, but the increase in duration was greatest relative to normal monsoon conditions (2.3 times longer) in the upper reach, compared with a 43 percent increase in duration for the Padma charlands as a whole (Tables 3.19 and 3.21).

Assuming that agriculture and the charland economy are adjusted to normal monsoon conditions (the flooding averages for 1989-92 are simple averages for 1-in-1, 1-in-2, and 1-in-5 year floods; Table 3.22), then a comparison of Figures 3.31 through 3.34 with 3.35 and 3.36 shows the areas that are likely to have suffered the most crop damage. If the 1987 or 1988 maps show a darker color in the scale of yellow through green to blue, then flood extent, flood duration, or both were greater than normal. While comparison of the flood extent and duration maps indicates where flood damages to crops are likely to have occurred, homestead land and house plinths are usually raised. In the island chars, however, the RRA found that homesteads were hardly raised, so the flood duration data may be relevant to flooding of

AVERAGE PEAK FLOOD EXTENT 1989-92

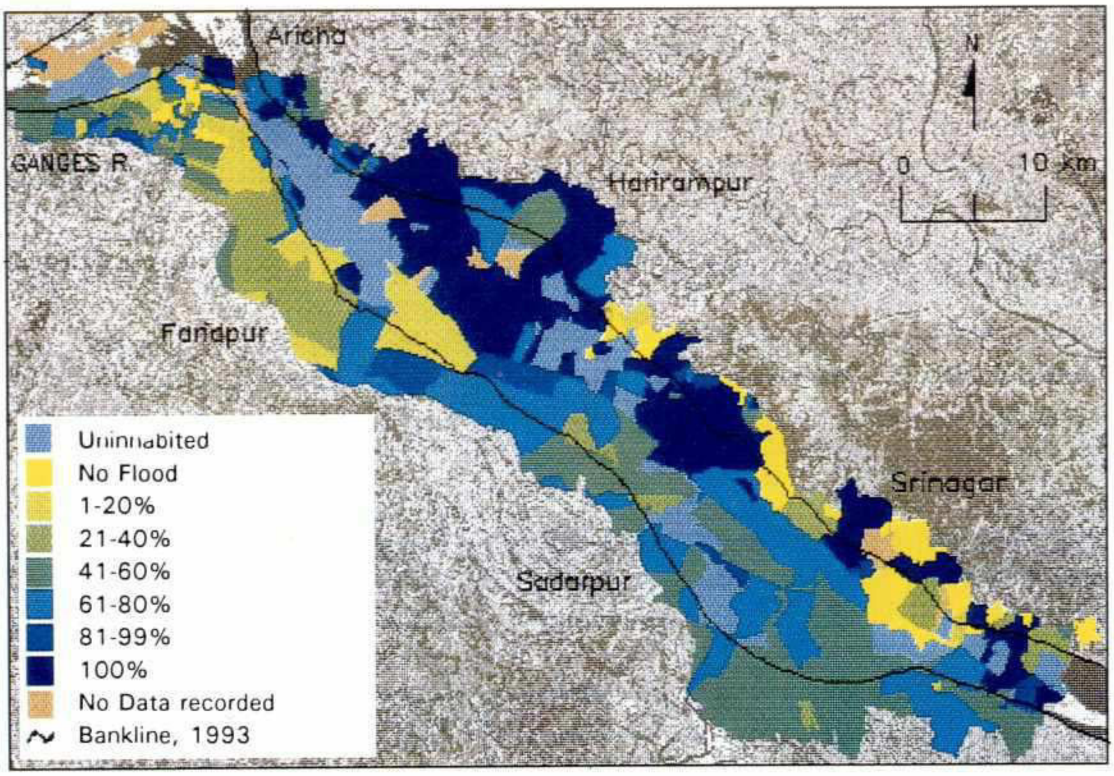

Figure 3.35

Source: ISPAN, 1993 Field data

AVERAGE PEAK FLOOD DURATION 1989-92

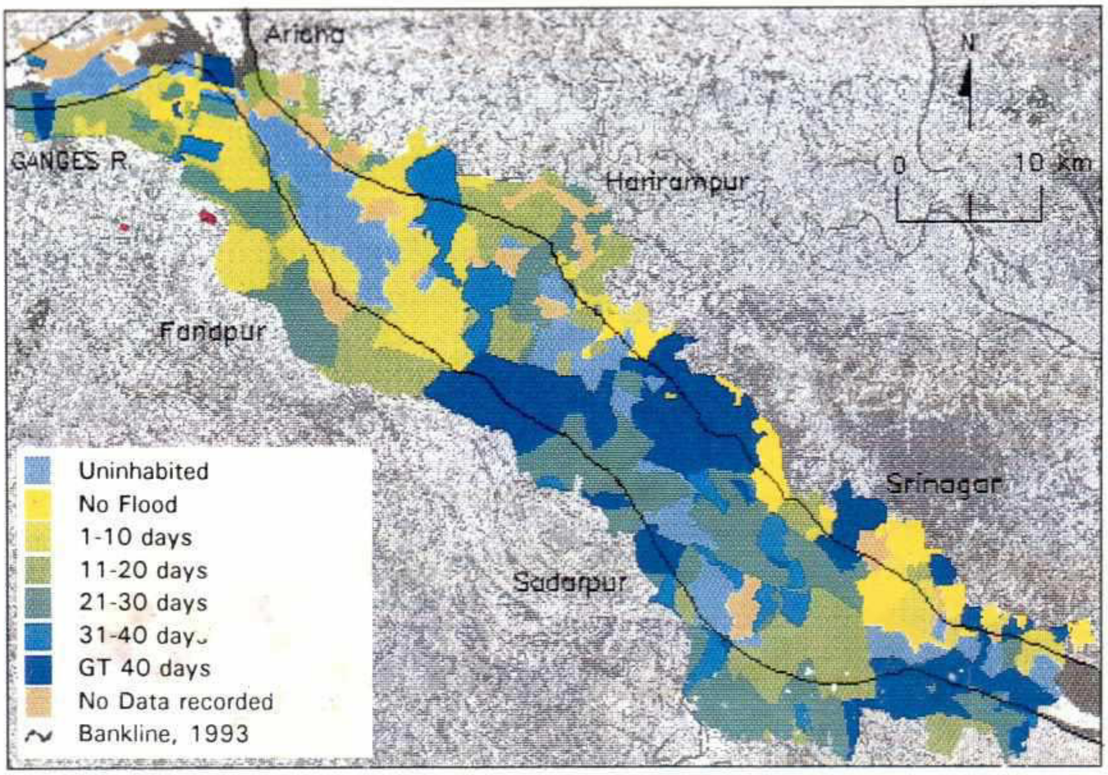

Figure 3.36

Source: ISPAN, 1993 Field data

houses in these areas. Section 3.6.3 reports evidence of flooding to houses.

Flood frequency analysis by FAP 25 is available for two BWDB gauging stations on the Padma: Baruria on the west bank of the upper reach, where the river is relatively narrow, and Mawa on the east bank of the lower reach, again where the river is relatively narrow (FAP 25, 1992). Table 3.22 gives the frequency of annual maximum water levels (flood peaks) estimated by FAP 25, and shows that the 1987 flood was a moderate-to-severe flood on the Padma with a return period of about 1-in-22 years in the upper reach. The 1988 flood was severe, with a return period of between 1-in-50 and 1-in-60 years. Although water levels in 1989 were no more than normal monsoon inundation, in 1990 and 1991 flood severity varied between the upper and lower reaches, within the normal-to-moderate range (1-in-2 to 1-in-6 year events).

The inventory reports from 1988 are consistent with the severity of the flood shown in Table 3.22. The inventory reports indicate that 1991 was no more than average for the period 1989-92, and the 1-in-6 year return period estimated for Mawa in that year was not associated with unusual flooding. The 1987 flood falls between the normal and extreme events but the inventory suggests it was a short-duration flood peak, and it appears to have affected mainly the upper and middle reaches. Key informant's estimates of flood extent and duration appear consistent with the flood frequency analysis. Normally, then, 60 percent of land in the Padma charlands is flooded in the monsoon, in a 1-in-20 year flood about 70 percent is flooded, and in a 1-in-50 year event all land is flooded.

3.6.3 Flood Impacts on Housing

A homestead's vulnerability to flooding depends in part on its structure. Both the materials a house is made of and the level of its floor and plinth (foundation) in relation to flooding levels are important factors. For this study house construction was categorized as either *kutcha* (made of straw, jute sticks, grasses, and/or bamboo) or *pucca* (made of corrugated iron, bricks, or concrete). In the Padma study area very few *pucca* houses are constructed of brick or concrete, most were made either entirely of CI sheet (corrugated and galvanized iron) or, more commonly, had CI roofs and *kutcha* walls. Better construction generally implies more resources and indicates a household that may be able to support itself during a severe flood despite the lack of daily work and damage or destruction of crops. These households also may have spent more to raise their homes above flood levels, and their homes may be more strongly constructed and therefore less likely to collapse in a flood.

Thirty-six percent of houses in the study area are reportedly all *kutcha* (Table B.62). Fewer houses have CI sheet in their construction in the upper reach, but Table 3.23 shows that in the island and attached char mauzas 50 percent or more of houses are all *kutcha* (these are the areas where catkin grass is readily available). Figure 3.37 shows that these mauzas (orange and pink) are concentrated in the more dynamic and recently accreted char areas. In the more stable unprotected mainland a majority of houses are CI sheet or have CI roofs

Table 3.23 Percentage of All-*Kutcha* Houses by Char Type

Char Type	Percentage *Kutcha*
Island Char	53
Attached Char	50
Unprotected Mainland	30
Total	36

Source: Table B.62

HOUSE CONSTRUCTION

PROPORTION OF HOUSES WITH TIN OR BRICK IN CONSTRUCTION

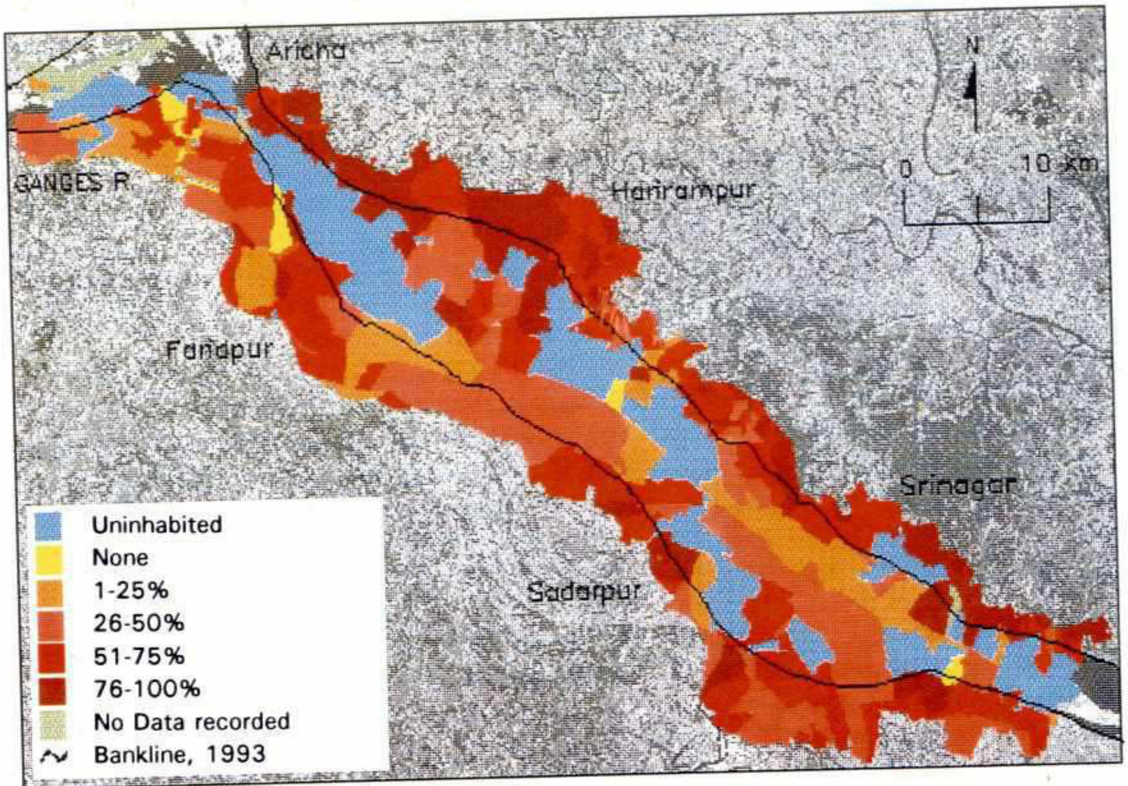

Figure 3.37

Source: ISPAN, 1993 Field data

HOUSEHOLDS SHELTERED IN MAUZA

PROPORTION OF HOUSEHOLDS SHELTERED ON PUBLIC OR OTHER PEOPLE'S LAND

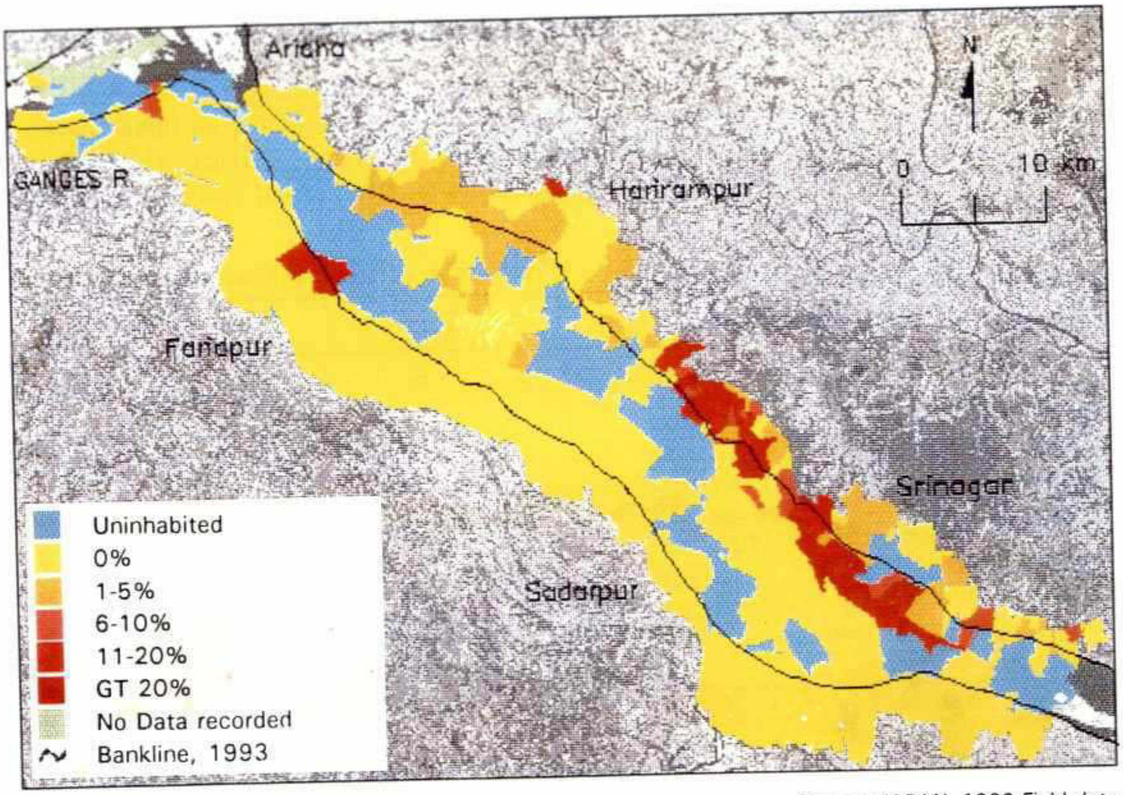

Figure 3.38

Source: ISPAN, 1993 Field data

(red and dark red). The inventory estimates indicate more houses of CI sheet in the island chars than was apparent in the RRA in the middle reach, even so, very few island char houses have CI walls compared with mainland areas.

Another factor affecting homestead flood vulnerability is the security of its tenure. Temporary houses are likely to be less substantial, their residents to be poorer and economically and socially dependent on others. Such households will face greater hardships during times of stress (such as floods). Figure 3.38 shows that households taking shelter in 1993 either on other people's land or on public land were almost all (except for a small area near Faridpur) concentrated in mauzas along the eastern bankline along the downstream half of the river. In these mauzas a high percentage (more than 10 percent) of households are sheltered, and the RRA found that these people were either living on embankments (including roadsides), or as *uthuli* on other people's land, or paying a rent for their homestead land. This area is somewhat less flood-prone than other parts of the study area, and is close to the chars that many of these households previously inhabited. Adjacent to part of this area there has been bank erosion, and island chars nearby have also submerged. However, much of this stretch of the bankline borders the large area of island char which accreted during 1984-93 (Chapter 2). More detailed study to understand why these people have not moved into these newly accreted lands is needed.

While houses are not usually moved in floods, people and possessions are often moved to higher places when flooding is severe. To do this effectively, sufficient warning is needed. The RRAs found that in past floods people most often reacted according to observations of rising flood water. Informants said radio broadcast information, while it was a preferred means of obtaining official warning, was often not relevant because it was not specific to their location. Table B.63 shows that access to radios is reportedly good, an average of about one radio to five households with little variation between reaches. Although there are fewer radios in the island chars (eight households per radio), this should still be ample to ensure that most households hear radio messages or would have a message passed on by their neighbors. If timely warnings that are meaningful to people in the Padma chars are broadcast by radio, there is a good chance that the messages will reach most people. Whether they can then save themselves and their property depends on the proximity of shelter and ease of access.

The inventory obtained estimates of the percentage of houses flooded (the percentages flooded above roof level were collected separately but are combined in the maps) and the percentage of houses destroyed in each year from 1987 to 1992. In many cases part of a "destroyed" house may have been salvaged. In Tables B.64 to B.69 the reach and char type percentages have been calculated by weighting mauza percentages by the number of households present in the mauza in 1993. In 1987, 27 percent of all houses in the Padma charlands were reportedly flooded, but Tables 3.24 and B.64 show that the situation was much worse in the upper reach, where 46 percent of houses were flooded, and in the lower reach virtually no houses were flooded. Figure 3.39 shows that a high percentage of houses were flooded within a limited area on the border of the upper and middle reaches, particularly in the attached chars. A lower percentage were affected at the confluence with the Ganges and Jamuna, and almost no houses were flooded south of Harirampur Thana. This differs somewhat from the flood extent data (Figure 3.31)

Table 3.24 Percentage of Houses Flooded by Year

Reach	1987	1988	1989-92*
Upper	46	100	3
Middle	29	100	4
Lower	3	94	1
Total	27	98	3

Source: Tables B.64, B.66, B.68
*Mean percentage for four years, 1989-92.

HOUSES FLOODED 1987

PROPORTION OF HOUSES WITH WATER ABOVE FLOOR LEVEL

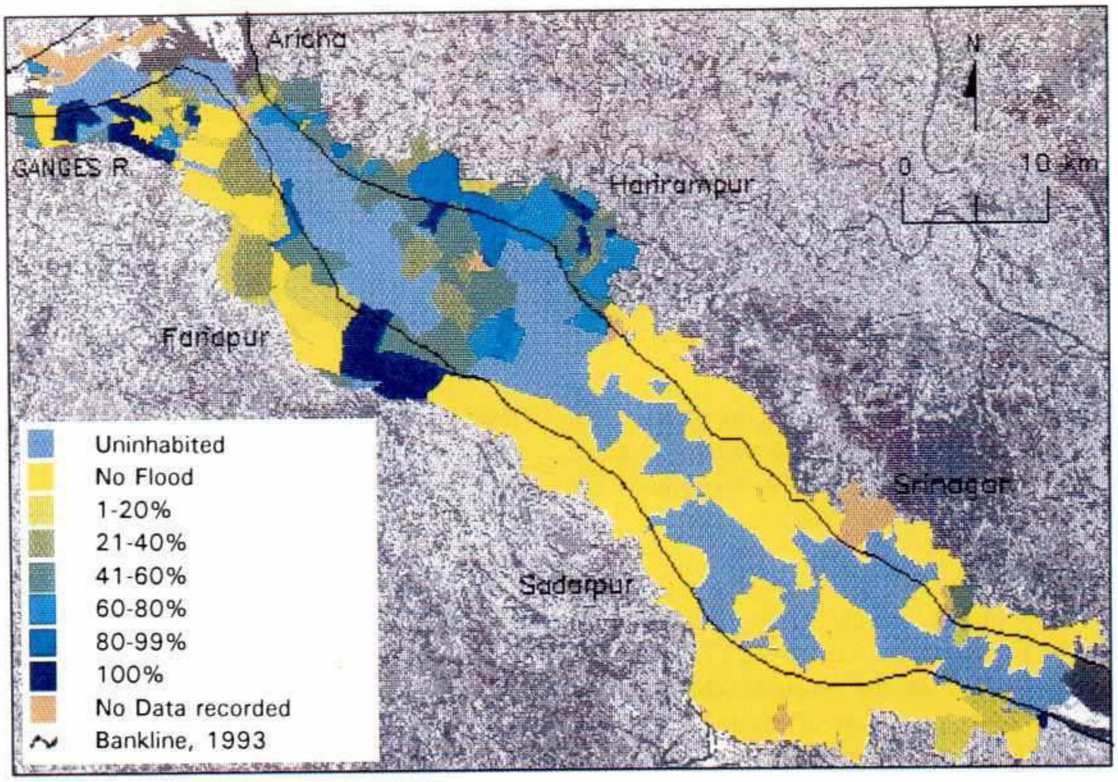

Figure 3.39

Source: ISPAN, 1993 Field data

HOUSES DESTROYED BY FLOOD 1987

PROPORTION OF HOUSES DESTROYED

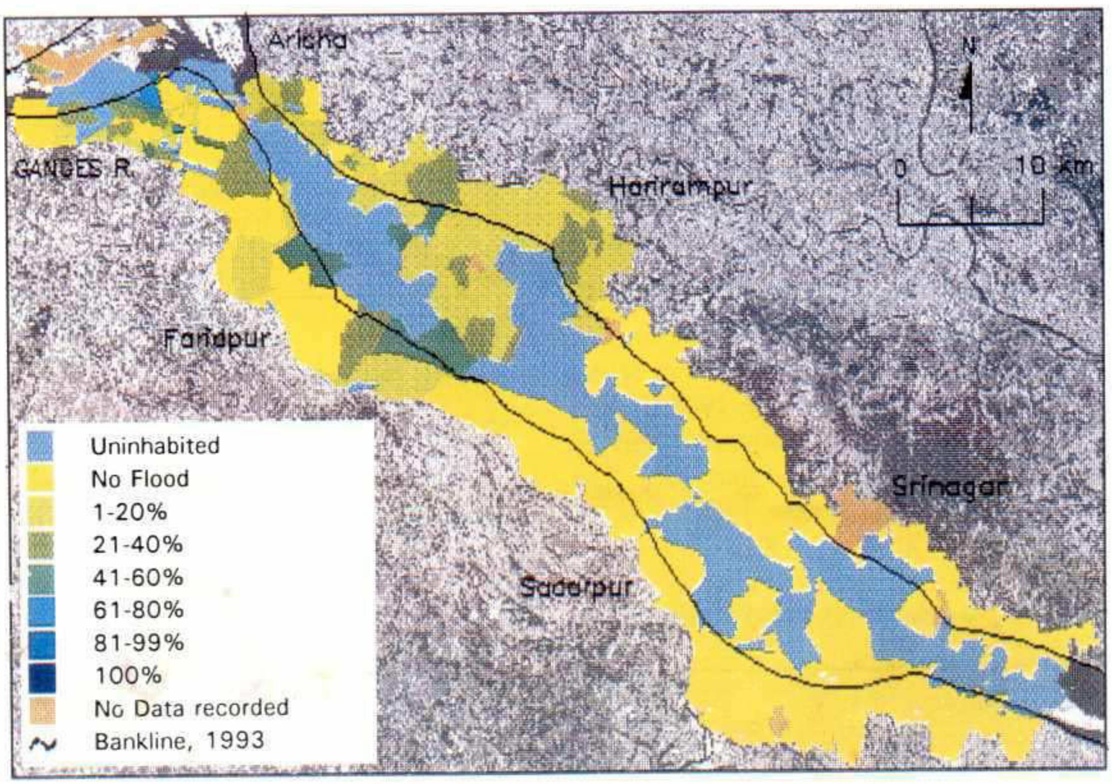

Figure 3.40

Source: ISPAN, 1993 Field data

Table 3.25 Percentage of Houses Destroyed by Flood

Reach	1987	1988	1989-92*
Upper	15	51	1
Middle	9	32	1
Lower	0	9	0
Total	8	31	1

Source: Tables B.65, B.67, B.69
*Mean percentage for four years, 1989-92.

which showed extensive flooding in parts of the lower reach. It may be that flooding was more severe in the upper reach (a peak flood level for Mawa is not available for 1987).

Relatively few houses were destroyed in the 1987 floods even in the affected area. Figure 3.40 shows that the 8 percent destroyed (Table B.65) were concentrated in the attached chars in the upper reach and upper part of the middle reach, where most homestead flooding occurred. It is possible that land is lower in this area, or that people are less well adjusted to floods.

In 1988, almost all study area houses were flooded (dark blue in Figure 3.41, averages of close to 100 percent in Table B.66). The only area where a few houses were not flooded was the lower reach west bank attached chars where 16 percent of houses were not flooded. Table 3.25 and Figure 3.42 show a clear trend in the percentage of houses destroyed from the upper reach, where 51 percent were reportedly destroyed, to the lower reach, where only 9 percent were destroyed. in the upper half of the study area many mauzas reported 60 percent or more houses destroyed in 1988 (blue shades), but the boundary of this area of housing destruction is almost identical to the limit of the area where houses were flooded in 1987 (Figure 3.39). This implies that homesteads are relatively low-lying in the upper part of the study area. The island chars appear not to have been as badly affected as attached chars in 1988 (Table 3.26), but this may be because many homesteads were eroded in some of these chars and were lost in this way rather than to flooding. People flooded in 1988 in some of the dynamic island char areas may also no longer be there, and informants may have had imperfect information on experiences in 1988.

The reason for extreme housing damage in the upper and middle reaches is clear from Table 3.27. While most houses were flooded in the Padma charland, depth in houses was greater in the upper and middle reaches, where more than 20 percent of houses were flooded to roof level. Charland houses are low-lying relative to flood risk in these areas, but they are only affected to this extent in a severe flood such as occurred in 1988.

On average between 1989 and 1992 there has been virtually no flooding of homesteads in the Padma charlands. Figures 3.43 and 3.44 show only a few mauzas where flooding and destruction of houses was reported, again in the upper reach east bank and extending into the middle reach. This reinforces the impression that homesteads in this area may not be adjusted to flooding. In the island chars of the middle reach some houses were just flooded above floor level in 1993 during the RRA (see plates). The inventory seems to have under-recorded flood experiences at least in the island chars. The RRA collected reports of some house flooding in 1991 in areas shown as having had no houses flooded (yellow) in Figure 3.43 for 1989-92.

Table 3.26 Percentage of Houses Destroyed by Char Type

Char Type	1987	1988	1989-92*
Island Char	10	40	1
Attached Char	14	50	1
Unprotected Mainland	6	24	1
Total	8	31	1

Source: Tables B.64, B.66, B.68
*Mean percentage for four years, 1989-92

HOUSES FLOODED 1988

PROPORTION OF HOUSES WITH WATER ABOVE FLOOR LEVEL

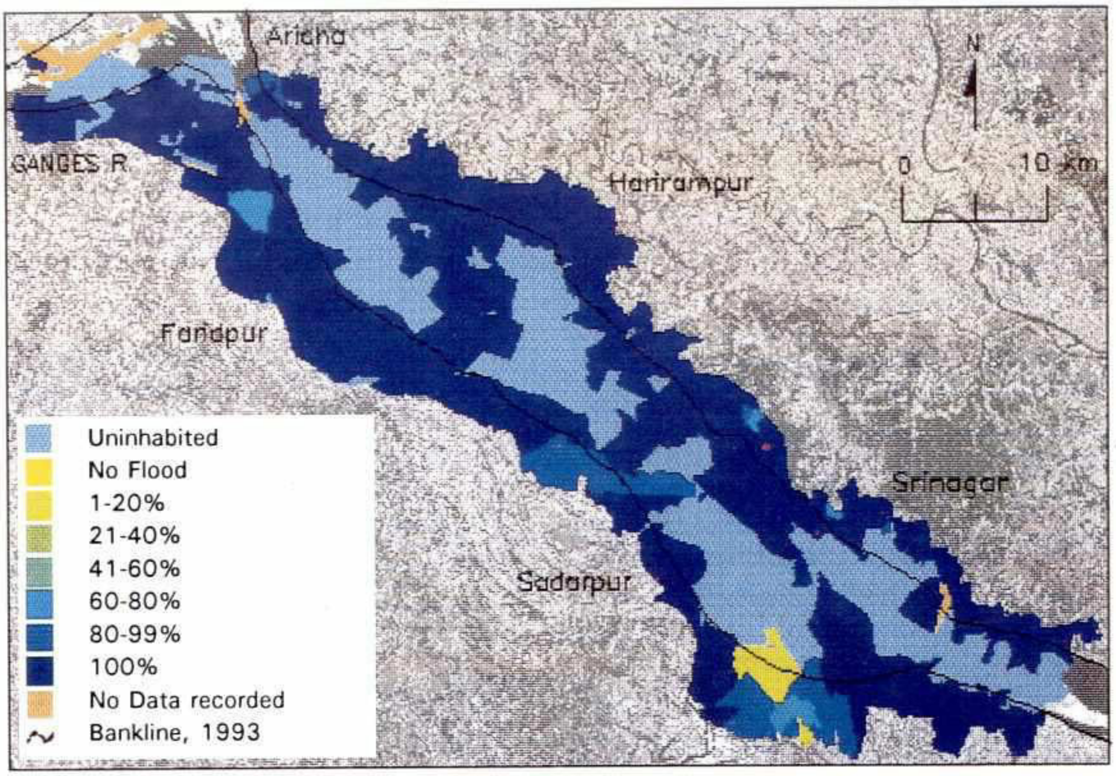

Figure 3.41

Source: ISPAN, 1993 Field data

HOUSES DESTROYED BY FLOOD 1988

PROPORTION OF HOUSES DESTROYED

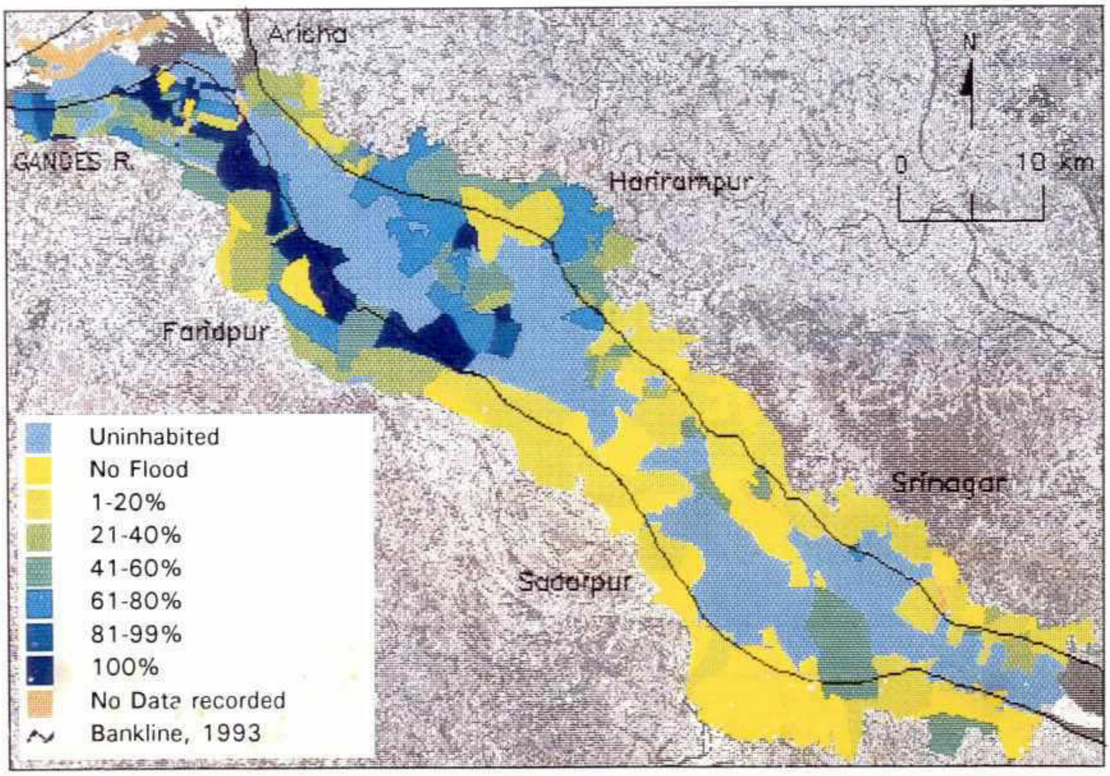

Figure 3.42

Source: ISPAN, 1993 Field data

Table 3.27 Percentage of Houses Flooded to Roof

Reach	1987	1988	1989-92*
Upper	5	27	0
Middle	1	22	0
Lower	0	9	0
Total	2	20	0

Source: FAP 16 Inventory
*Mean percentage for four years, 1989-92.

Compared with the 1989-92 average, in the 1987 flood about nine times more charland houses were flooded than normal, and in 1988 virtually all houses were flooded compared with the norm of 3 percent. Clearly, then, houses are very rarely destroyed by normal monsoon flooding. In the Padma charlands almost four times more houses were reportedly destroyed in 1988 than in 1987, and the most affected areas in both years were in the upper and middle reaches.

While the percentage of houses destroyed by flooding is clearly correlated with the flood return period, there is also a strong trend for damages to be less further downstream in the Padma, even though a much higher proportion of houses was reported destroyed in the Padma-Meghna confluence in 1988 than in the lower Padma (37 percent compared with 9 percent). It would appear that in the upper reach a flood about 1 m higher than normal results in just under half of the charland houses being flooded and about 15 percent destroyed, while a flood 1.4 m higher than normal results in all houses being flooded and half being destroyed, yet the same events result in much less flooding of houses in the lower reach. Further information on land and house levels would be needed to understand these differences.

3.6.4 Flood Risk

Flood severity and the risk of loss are apparently higher in the upper reach of the river than in the lower reach. This indicates a priority need for flood proofing interventions in the upper reach under the present river regime. Embankments proposed under the FAP could affect the Padma flood regime either directly, if existing embankments along the Padma are improved, or indirectly, as a consequence of construction or improvement of upstream embankments on the Ganges or Jamuna (including the proposed Jamuna bridge).

Modelling of peak water levels for a variety of embankment scenarios has been undertaken by FAP 25. Two of the scenarios in FAP 25 (1993) are particularly relevant to the Padma: improvements to the Jamuna embankments, Jamuna bridge plus the Ganges left embankment (Scenario 3), and Scenario 3 plus full flood control embankments along the Ganges and Padma (Scenario 5). Table 3.28 shows that in a normal year (1986, just over a 1-in-1 year peak level) there would be little impact. If a 1988-magnitude flood occurred with these interventions, the increase in water level would be an addition of between 55 and 100 percent of the increase between the 1987 and 1988 events. A 30 cm increase in flood depth between

Table 3.28 Changes in Peak Water Levels with Embankment Scenarios

Year	Scenario	Baruria	Mawa
1986	actual (m)	7.88	5.76
	3 (+)	.07	.04
	5 (+)	.11	.10
1987	actual (m)	9.04	na
	3 (+)	.14	.08
	5 (+)	.19	.17
1988	actual (m)	9.35	7.06
	3 (+)	.23	.17
	5 (+)	.33	.34

Source: FAP 25 (1992), FAP 25 (1993)
Scenario 3—embankment along Jamuna and Dhaleswari, Ganges left embankment and Jamuna Bridge.
Scenario 5—essentially full embankments along main rivers plus Jamuna Bridge. See FAP 25 (1993) for full details.

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HOUSES FLOODED 1989-92

AVERAGE ANNUAL PROPORTION OF HOUSES WITH WATER ABOVE FLOOR LEVEL

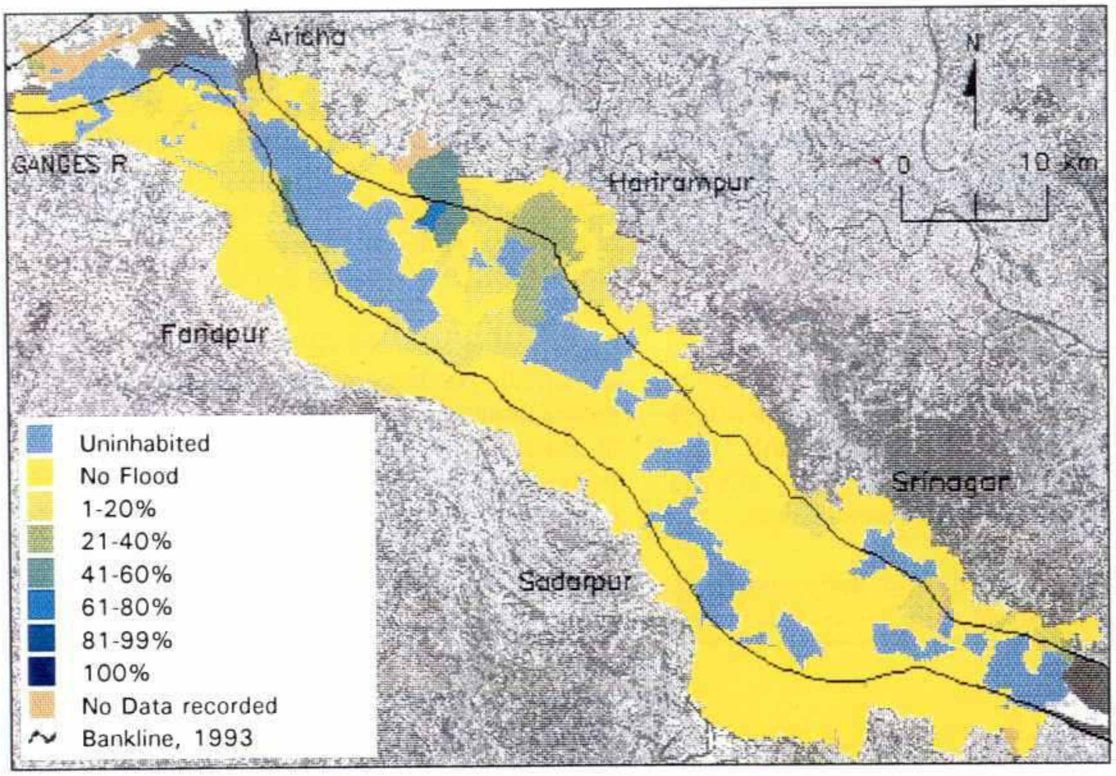

Figure 3.43

Source: ISPAN, 1993 Field data

HOUSES DESTROYED BY FLOOD 1989-92

AVERAGE ANNUAL PROPORTION OF HOUSES DESTROYED

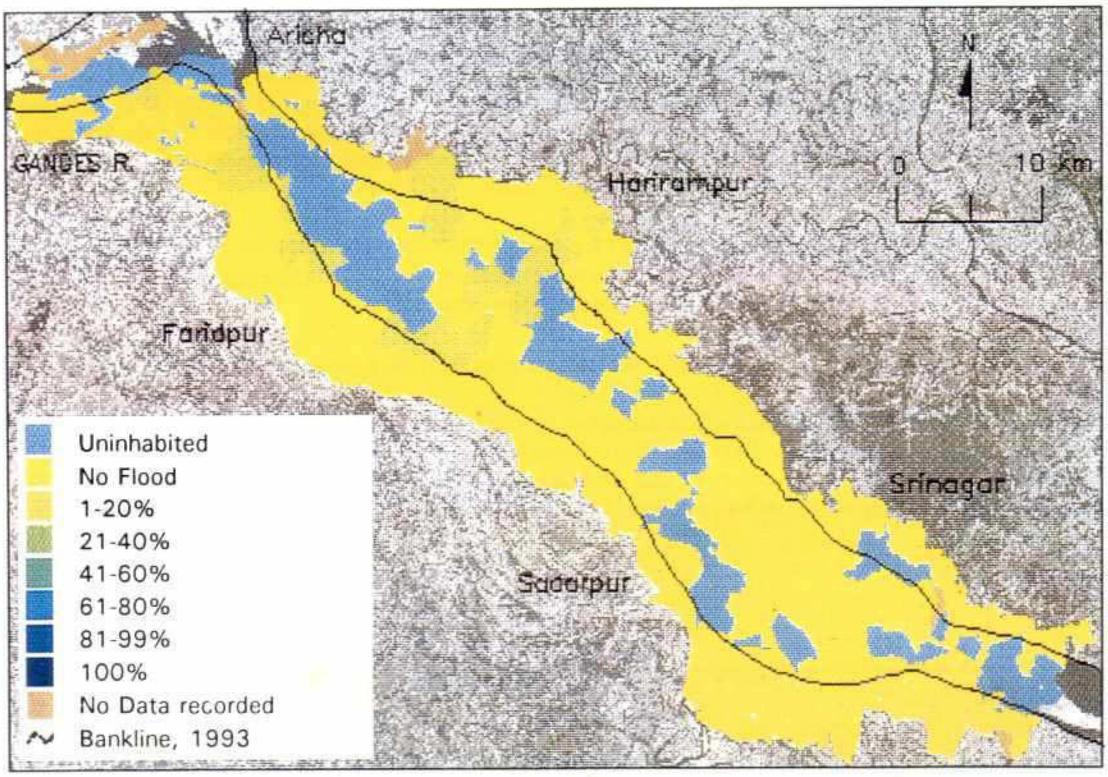

Figure 3.44

Source: ISPAN, 1993 Field data

1987 and 1988 is reported to have increased the number of houses flooded to the roof from about 2,300 (2 percent) to 23,000 (20 percent), and the number destroyed rose from about 9,200 to about 35,000. An additional 33 cm of flood water in the same flood event with Scenario 5 embankments would most likely increase damages by at least that much again in the Padma charlands.

Upstream embankment projects and embankments along the Padma, therefore, would worsen flooding in the Padma charlands (which would remain unprotected). Even if no further work to embank the Padma was undertaken but the Jamuna bridge and Jamuna left embankment were built, char people in the Padma would be adversely affected in extreme floods, but not in normal floods.

Additional data are needed to more accurately model flood impacts and the potential benefits of flood proofing measures. Accurate ground level and property information need to be linked to inventory data and hydraulic modelling via mapped outputs from a digital elevation model (DEM). Failing this, a series of satellite images on a rising and falling flood would be useful, or images of flood peaks in successive years plus rapid damage assessment surveys. Unfortunately, it is currently difficult to procure either the cloud-free data or radar imagery that would be required.

The inventory data and GIS indicate that the upper and middle reaches are a priority for measures to reduce flood impacts, although this is not necessarily the case for other interventions. More detailed study of the perceived needs of char people, flood impacts, local topography, and flood risks in particular reaches are needed before appropriate local flood proofing interventions can be designed.

NOTES

1. Population data from the 1991 census are not yet published for the Padma area. The estimates reported here were based on information from Union Parishad Chairmen or Members wherever possible, and reflect the local "official" figures at the time of the survey, cross-checked with residents of the mauzas. The household numbers given in the inventory are believed to be generally reliable, and household sizes inferred in the inventory are consistent with Bangladesh averages. Comparison between the 1992 Brahmaputra-Jamuna inventory estimates and more detailed household listings for sample surveys, however, suggested that there is a risk that the numbers, but not the proportions, derived from the inventory may be too high on average.

2. The study area included parts of many mauzas, so it was not appropriate to analyze a chairman's residence on a union basis.

3. BBS (1993) defines cropping intensity as total cropped area divided by net cropped area times 100. The inventory obtained estimates of the percentage of cultivable land cultivated under each crop type. These percentages have been summed to get mauza-level estimates of cropping intensity for Figure 3.16. In a small percentage of mauzas the percentages totalled less than 100 percent (but not less than 90 percent), indicating some current fallow in the past year and slightly reduced the estimated cropping intensity. For the tables, the percentage of land cultivated was weighted by the cultivated/vegetated area estimated from the 1993 satellite image in order to estimate the total areas under each crop and relate this to the total cultivated area.

4. These frequencies or return periods of flood damages, based on the period 1988-92, are only indicative. They simply state, for example, that in the upper reach *aus* reportedly was damaged by floods twice in the past five years on average. Damages have been frequent, therefore, given that 1988 was the only severe flood year among the five considered.

5. The data summarize experience over an unspecified number of years so these events may have occurred during past land accretions.

6. Figure 3.30 also shows that many more mauzas were uninhabited (blue) in 1988 than in 1993, suggesting substantial accretion and resettlement since 1988. Some mauzas may have been inhabited at that time but in 1993 no one was available to recall flood experience in 1988. Key informants, however, generally appeared to be well informed about submergence and resettlement. In Figure 3.29, therefore, the predominant hazard resulting in death is only estimated from the years during 1988-92 when the mauza was inhabited.

Chapter 4

ANALYSIS OF POPULATION TRENDS WITH CHANNEL DYNAMICS

4.1 Data Sets

The Landsat satellite images and analysis of river morphology reported in Chapter 2 constitute a database for the Padma that is independent of mauza boundaries. The inventory data on populations and resources is not easily divisible below the mauza level—the primary data collection unit. Despite this limitation on the degree the two data sets can be integrated, the alignment of mauza boundaries with the image data is reliable. At the mauza level, then, links between the data sets can be made.

The objective of the analysis in this chapter has been to estimate the potential aggregate impact of erosion and accretion on population and migration. This has been done for:

- population density relative to age of land (Section 4.2);
- reported areas and numbers of homesteads lost to erosion in each year from 1987 to 1992 (Section 4.3); and
- longer-term bank changes (erosion) between 1984 and 1993 relative to 1981 and 1993 populations (Section 4.4).

4.2 Population Density and Age of Land

The total 1993 population of the Padma Charland Study area is estimated to have been about 0.62 million people (Section 3.2); compared with 0.58 million in 1981. This represents an increase of only 6 percent. The 1993 population density of the area was 569 people per km^2 (total area, including water), and 967 people per km^2 of vegetated or cultivated land. By comparison, the national population density in the 1991 census was 763 people per km^2 (BBS, 1993).

Population density estimates from the 1993 inventory relative to vegetated/cultivated land are mapped in Figure 3.6. Age of land, which was mapped in Figure 2.10, and population density show some association. Table 4.1 shows that, in aggregate, mauzas where the land is reported to be 10 years old or less have 473 people per km^2 of vegetated/cultivated land, compared with 1,553 people per km^2 in mauzas where the land is more than 70 years old. Only inhabited mauzas have been considered since uninhabited mauzas were either submerged or there was no one to estimate the age of any land present.

Table 4.1 Population Density in 1993 by Age of Land*

Land Age (years)	Aggregate people per km^2
1-10	473
11-20	735
21-30	671
31-70	956
71+	1,553
All land+	1,041

Source: Inventory survey
*Excludes mauzas which were uninhabited but cultivated.
+Includes mauzas for which age of land is not known.

These population densities are higher in each category than in the Meghna charlands, and the population living on relatively new land is particularly high, indicating that the land is productive and that there is strong pressure to settle new land. Most (60 percent) of the mauzas in the youngest land age category were 1-5 years old in 1993. Population density appears to be more closely related with land type than with land age in the Padma charlands[1].

The fact that older land is more densely populated is probably related to higher productivity of this land. In the char areas as the accreted land matures, the organic material in its soil may increase, enhancing agricultural productivity. There also has been more time for people to move onto older chars. Furthermore, the mainland areas (outside the banklines) had higher population densities than the char areas, and within the mainland areas older land on the east bank had higher population densities than land which had accreted within the memory of informants (21-70 years ago). Some of these areas are now threatened by river erosion. Even if equivalent areas of charland are accreted to compensate for the eroded mainland, therefore, it seems that they would not be able to support the same number of people for many years.

4.3 Recent Erosion of Land and Homesteads

The inventory survey asked key informants to estimate the areas of land, number of homesteads, and number of lives lost to erosion in each year from 1987 to 1992. As Section 3.6.1 showed, very few lives were reported lost due to erosion.

The total study area is 108,822 ha, of which in January 1993 there were 63,982 ha of vegetated or cultivated land (Tables B.1 and B.4). While it is likely that informants' estimates of areas lost are subject to some error, the differences between years should indicate the relative severity of erosion in each year. Because the area of land actually present in the study area in each of the years from 1987 to 1992 could not be estimated independently, actual areas reported by informants rather than percentages were used in the analysis.

Figure 4.1 shows the distribution of mauzas reporting erosion of land in the peak flood year of 1988, when a total of 2,000 ha were said to have eroded (Table B.71). Concentrations of erosion in areas close to the 1993 bankline are apparent from the Jamuna confluence near Aricha in the west to the narrowing of the Padma at the eastern end of the study area. Comparison of Figure 4.1 with Figure 2.7 (showing the migration of low-flow channels) reveals that this reported erosion mostly took place where the meanders in the main channel have been cutting into the banks between 1984 and 1993. About 50 percent of the erosion took place in island char mauzas, but in the lower reach these mauzas may well have been mainland in 1988 as there has been a major shift in the river channel in this area.

The pattern of erosion reported in 1987 was similar to that shown in Figure 4.1 for 1988. More than 50 percent of the area eroded was in the lower reach in both years (Table B.70), with 53 percent of 1987 erosion in lower reach island chars, and 36 percent of 1988 erosion in the same island char area. Less than 10 percent of the area eroded was in the upper reach. Also, the annual average area eroded in 1989-92 was 51 percent of the area reported eroded in 1988. This confirms the finding from the Jamuna that there is more erosion in peak flood years.

As expected, Figure 4.2 confirms that homestead erosion in 1988 was concentrated in the same

Table 4.2 Percentage of Eroded Homesteads in Each Reach

Reach	1987	1988	1989-92
Upper	17	19	4
Middle	34	38	51
Lower	49	43	44
Total (no.)	436	1,347	2,935

Source: Tables B.73 to B.75

AREA ERODED 1988

PROPORTION OF TOTAL MAUZA AREA ERODED

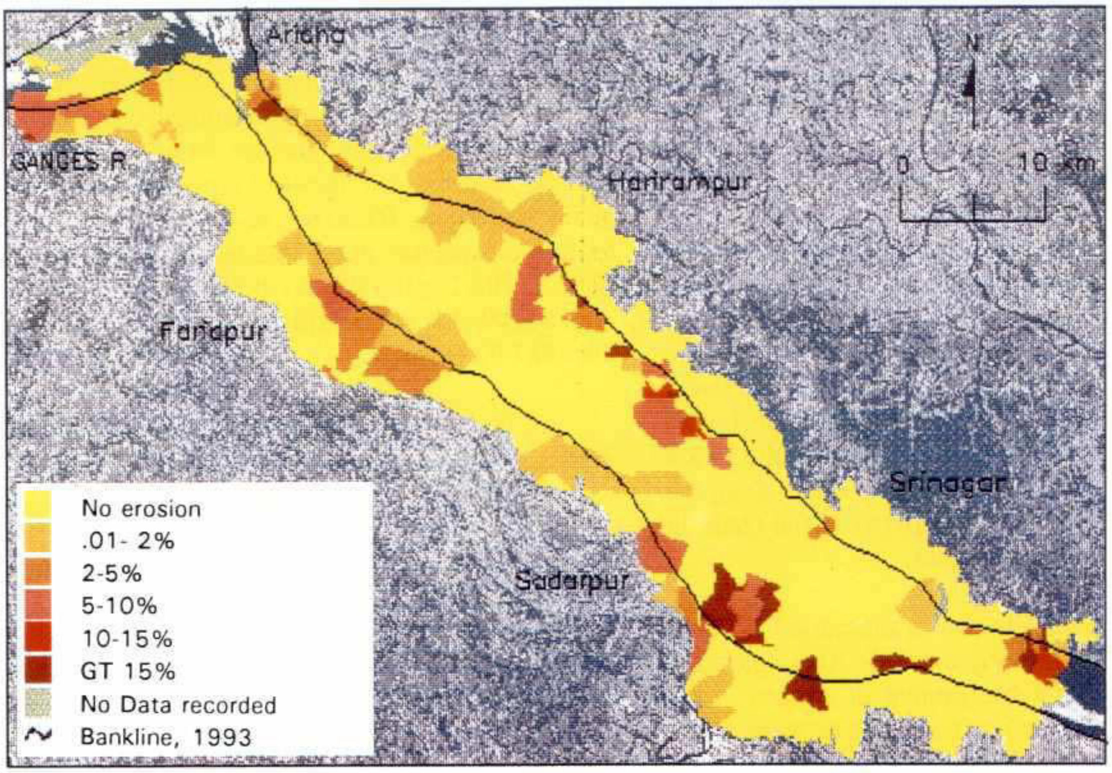

Figure 4.1

Source: ISPAN, 1993 Field data

HOMESTEADS ERODED 1988

PROPORTION OF 1993 HOUSEHOLDS ERODED

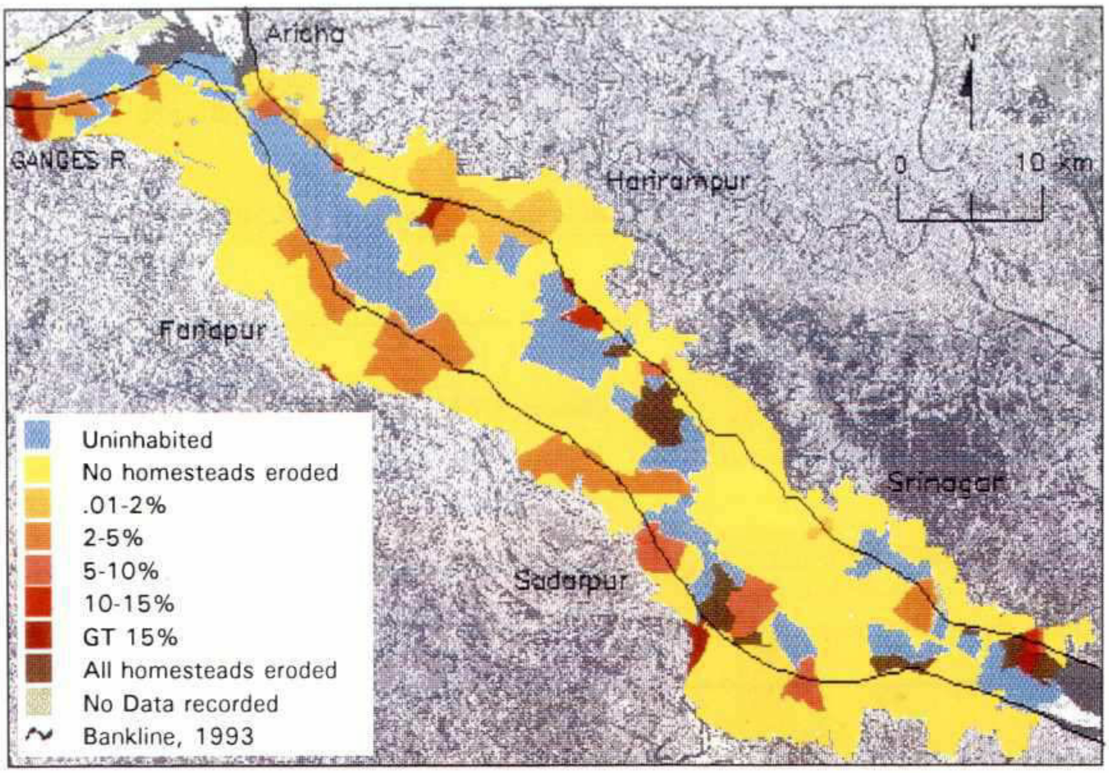

Figure 4.2

Source: ISPAN, 1993 Field data

mauzas that experienced land erosion. Homesteads in the lower reach fared best that year in comparison with the percentage of land eroded: 43 percent of homesteads eroded, but 57 percent of the land area washed away. Thirty-eight percent of eroded homesteads in 1988 were in the middle reach where island chars and mainland were equally affected. There may have been relatively more people living close to the bankline in 1988 in this reach. Although more than one household may live in a homestead, the only available data with which to show the relative severity of homestead erosion was the 1993 number of households (this underestimates the number of households affected). Locally, more than 15 percent of households were eroded in 1988 (dark red in Figure 4.2) along the banklines and in several scattered island chars in the middle and lower reaches.

The distribution of erosion in the period 1989-92 was rather different (Figure 4.3). Although there was still a considerable amount of erosion in the lower reach, the main concentrations were in the middle reach, where 67 percent of the area was said to have eroded (Table B.72). Figure 4.3 shows that this erosion affected mauzas along both banklines, and suggests most recent widening has taken place at the slight constriction in the middle of the Padma.

More than twice the number of homesteads were reported eroded between 1989 and 1992 as were lost in 1988, from which can be inferred an annual loss of 54 percent of that in 1988. Homestead losses were widespread in both the middle and lower reaches from 1989 to 1992. The majority of those lost were in the island chars and east bank unprotected mainland in these two reaches (Figure 4.4), with a relatively high number of homesteads lost in the middle reach island chars. Table 4.2 shows the relative increase in homestead loss to erosion in the middle reach between 1987-88 and 1989-92 which coincides with the changing pattern of reported erosion of land.

The inventory reports indicate that in the Padma area a total of 4,718 homesteads eroded (including both bank and char erosion) between 1987 and 1992 and their households were forced to move. Of these, 32 percent were in island char mauzas and may have been displaced by within-channel erosion. Because the number of homesteads is not known, Figures 4.2 and 4.4 assumed one household per homestead to give an indication of the relative severity of homestead erosion, but this is an underestimate. Based on the RRA surveys, four to five households per homestead may be more typical. This implies that up to 20 percent of study area households were displaced by erosion during the 1987-92 period.

4.4 Changes in Population and Mainland 1980-92

4.4.1 Aggregate River Bank Changes

This section is based on calculation of areas lost to erosion or accreted along the west and east banks of the river between 1984 and 1993. The areas derived from the satellite image analysis have been summed on a mauza basis, then related with population data from the 1981 census and 1993 inventory.

Mauzas that were entirely within the channel in 1984 and 1993, and mauzas that were entirely on the mainland (not touching the bankline) in 1984 and 1993, were identified separately in order to check population trends in the two charland types that were unaffected by bank erosion. Mauzas

Table 4.3 Summary of Study Area

	Area (ha)
Mainland, 1984	66,934
Channel, 1984	41,849
Total, 1984	108,783
Mainland Eroded 1984-93	16,206
As Percentage of 1984 Mainland Area	24.2

Source: FAP 19 satellite image analysis

AREA ERODED 1989-92

TOTAL AREA ERODED AS PROPORTION OF MAUZA AREA

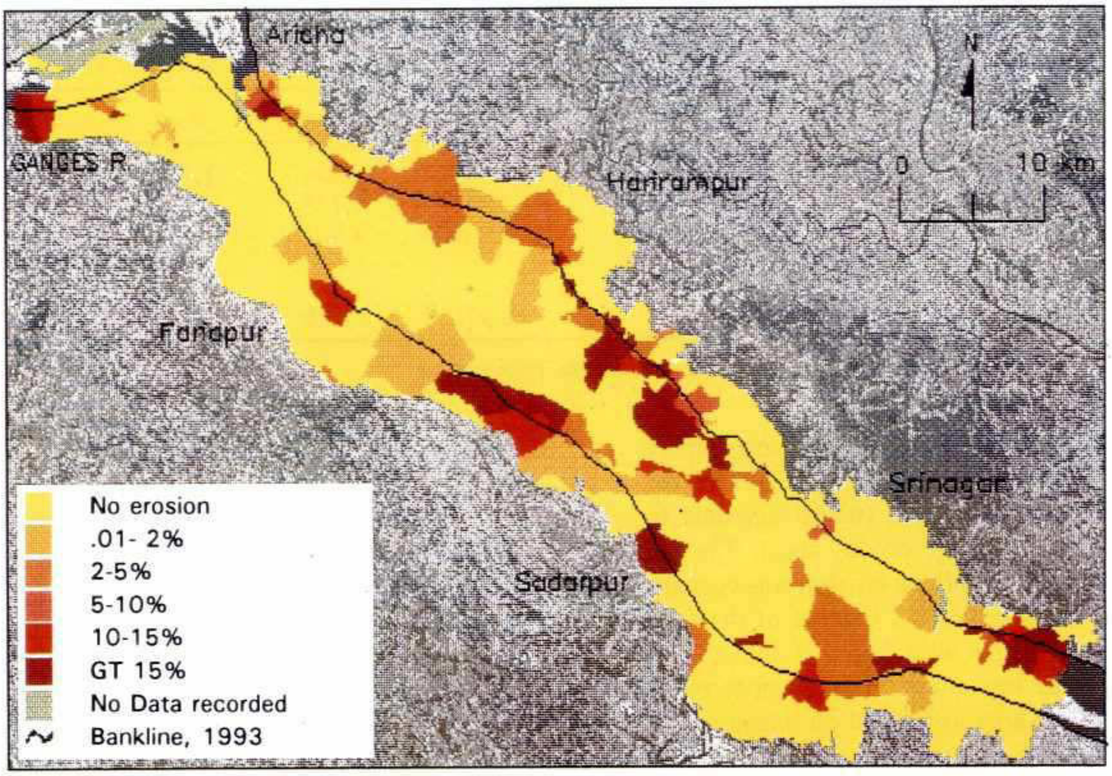

Figure 4.3

Source: ISPAN, 1993 Field data

HOMESTEADS ERODED 1989-92

1989-92 TOTAL HOUSEHOLDS ERODED AS PROPORTION OF 1993 HOUSEHOLDS

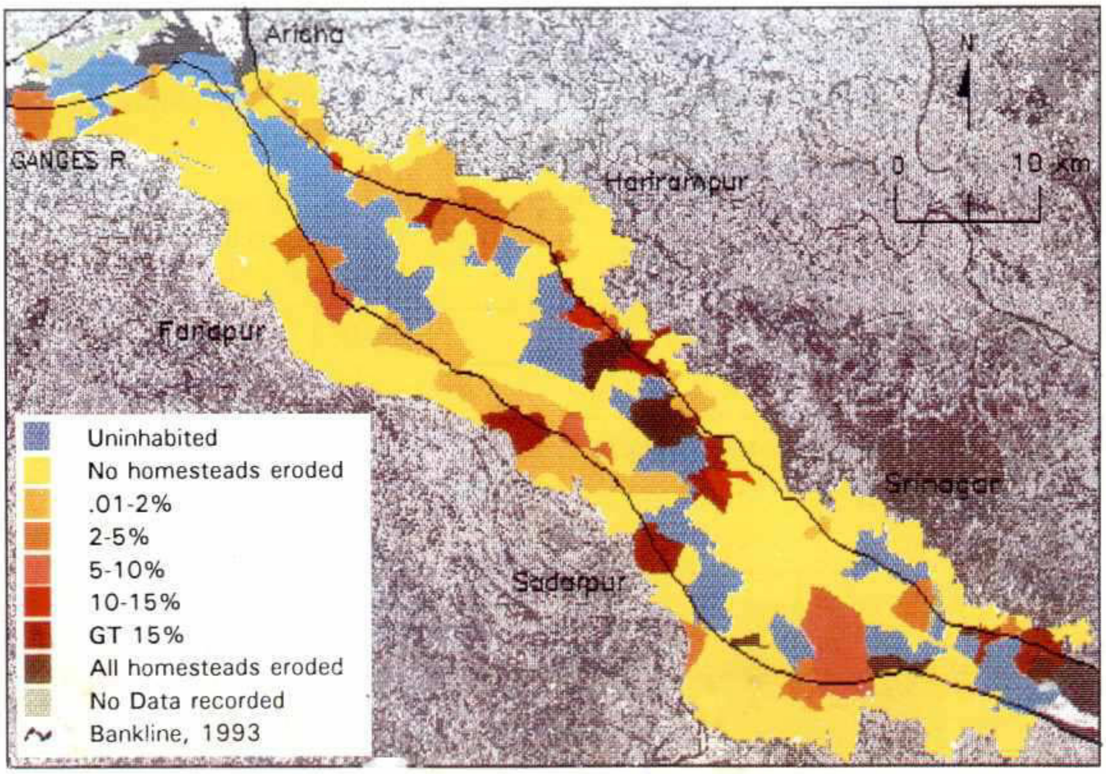

Figure 4.4

Source: ISPAN, 1993 Field data

within the channel still have experienced erosion and accretion, but this analysis concentrates only on bank erosion. The total areas are from the same image analysis as was used in Section 2.5, but here they have been summed for all mauzas in the study area.

Table 4.4 Net Area of Bank Erosion and Accretion, 1984-93

Reach	Eroded (ha)		Accreted (ha)	
	West	East	West	East
Upper	842	956	1,155	8
Middle	4,267	1,776	0	134
Lower	3,862	4,503	640	157
Total	8,971	7,235	1,795	299

Source: FAP 19 satellite image analysis

Table 4.3 shows that, in the Padma study area, 24 percent of the 1984 mainland had been eroded by 1993 and converted into channel (river and chars combined). Table 4.4 breaks down this erosion by reach and bank, along with the small area of net accretion in the same period (which amounts to only 13 percent of the net eroded area). The net area lost was 14,112 ha. Bank erosion was concentrated in the lower reach (52 percent of the total area lost), and in the west bank of the middle reach. There was less erosion in the upper reach (11 percent of the area lost based on image analysis) but this is more than was reported in the inventory. Accretion was concentrated in the upper reach (56 percent) at the Ganges-Jamuna confluence.

It should be remembered that this analysis ignores many of the morphological changes that may have occurred during the period. For example, some areas may have eroded and accreted within the period of analysis. Figure 4.5 shows the areas eroded and accreted between the 1984 and 1993 dry season satellite images overlaid on the mauza boundaries.

Table 4.5 Population by Land Status, 1981-93

Population in:	1981 Number	1981 %	1993 Number	1993 %
Unprotected Area	584,168	100	618,655	100
Within Banklines	87,327	15	122,929	20
Eroded Area 1984-93	123,638	21	0	

Source: 1981 BBS census and 1993 FAP 16 inventory

4.4.2 Population Dynamics

Table 4.5 summarizes the 1981 and 1993 population in the study area. The population displaced by erosion can be estimated given three assumptions:

- that all of the 1981 population living in mauzas intersected by the bankline actually lived on the mainland (a few may have been on island chars within the same mauza, but there were few such cases in the Padma in 1981-84 and population density is low on island chars);
- that this population was evenly distributed over land whether it eroded in the period 1984-93 or was not lost; and
- that the population had not moved significantly, nor the bankline changed significantly between the 1981 census and 1984 image[2].

The population changes that would have occurred after 1981 on that eroded land are unknown, as is the year of erosion for any particular location. Table 4.5 summarizes the 1981 population and the population estimated to have been displaced by bank erosion in this period, a total of 123,638 people—about 21 percent of the study area population in 1981, which is similar to the inventory-derived estimate in Section 4.3.

Bankline Changes 1984-93 With Mauza Boundaries

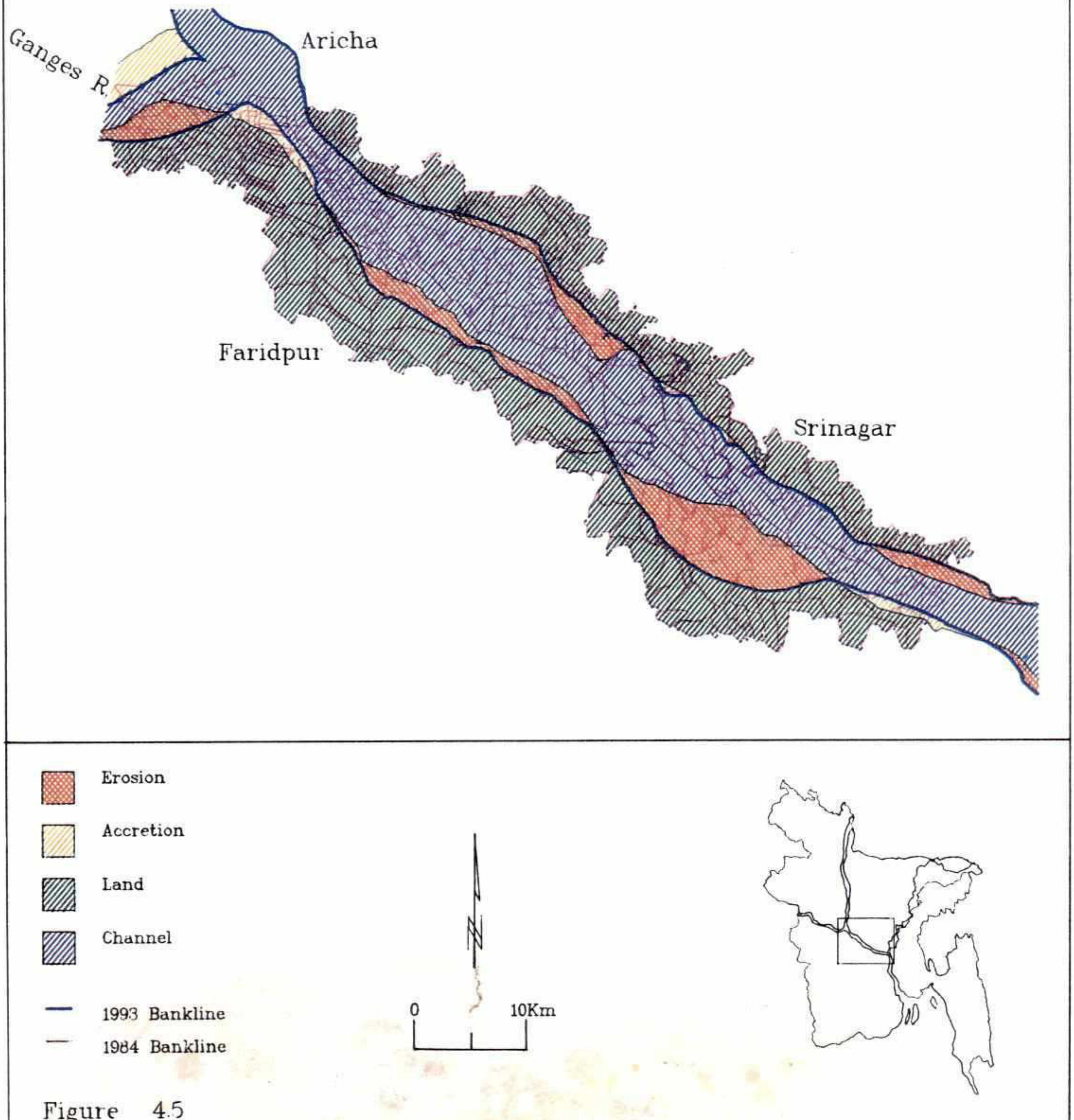

Figure 4.5

Table 4.6 **Estimated Population of Land Lost to Bank Erosion 1984-93**

	Percent of 1984 Population		Population Density in 1984 (per km²)	
Reach	West	East	West	East
Upper	7	7	501	535
Middle	51	32	741	1,286
Lower	42	61	676	964
Total	61,941	71,341	691	986

Source: BBS 1981 Census data multiplied by 1.078 and apportioned according to area estimates from FAP 19 image analysis

Normal population growth most likely would have resulted in somewhat more people being displaced as erosion progressed. Moreover, it is likely that households moved more than once during this period because of successive bank erosion events, but the history of population displacement cannot be gauged from the available data.

Assuming that population growth on eroded land took place at the national average rate during 1981-84 (7.8 percent increase), and that all erosion took place in 1984 (conservative assumptions because of uncertainty about the sequence of erosion events and population shifts), then some 133,000 people were probably displaced by bank erosion. Table 4.6 gives estimated populations in 1984 affected by erosion during 1984-93. Population density on this land in 1981 averaged 763 people per km² of land (based on Table 4.6), which is 13 percent higher than the density in 1981 for mainland unaffected by erosion during 1984-93 (674 people per km² of land). The satellite images (Figures 2.1 and 2.2) indicate that most of the land eroded during this period was old mainland where the large meander east of Sadarpur has cut into the banks. This land presumably had a high population compared with other areas which were not affected by erosion, such as the attached chars in the west bank upper reach which remained outside the bankline during 1984-93.

Although similar numbers of people were estimated to have been displaced by erosion of the west and east banks, on the east bank they were concentrated in the lower reach, while on the west bank they were spread between the middle and lower reaches. Population densities in 1981 on the eroded mainland were slightly higher than comparable unaffected mauzas on the west bank, but were the same as other mauzas on the east bank. The low population densities on eroded mainland mauzas in both banks of the upper reach are consistent with the population density for this reach as a whole in 1981.

Accretion resulted in a small compensating gain of 2,094 ha of land, much of it near the Ganges confluence. Assuming the same population density as found in these mauzas as a whole, this land was much less densely populated than other mainland areas, having 606 people per km² in 1993, or a total of about 12,700 people (the majority of them in the west bank of the middle and lower reaches). The net impact was that mainland which had supported 120,582 people was lost to bank erosion, although the area of island chars increased in the same period.

As Chapter 2 explains, the river channel, particularly in the middle and lower reaches, was widening during the period studied. While it has not been possible to relate population changes with in-

Table 4.7 **Population Growth in Within-Bankline Mauzas (area = 19,097 ha)**

Reach	1981 Population per km²	1993 Population per km²	Percent Change
Upper	1	31	+3,000
Middle	75	74	-1
Lower	43	227	+428
Mean	58	111	+92
Total People	11,156	21,275	10,119

Source: BBS 1981 Census; inventory data; FAP 19 satellite image analysis channel morphology, the population trend in mauzas remaining completely in-channel over the period has been assessed. Table 4.7 shows a substantial increase in population in these mauzas. In the upper reach few people live within the banklines as there is very little habitable land on island chars, so the small number of people in this area in 1993 represent a very large increase. In the middle reach the population within the banklines has stayed constant, which is consistent with the area of island chars being similar but rearranged by within-channel changes (Chapter 2).

Table 4.8 Population Growth in Unaffected Mainland Mauzas (area = 33,016 ha)

Reach	Percent Growth/Decline 1981-93 West	East
Upper	51	43
Middle	55	57
Lower	3	30
Average	31	47
Total Population 1981	121,327	101,106
Total Population 1993	158,492	148,739
People per km² 1981	551	920
People per km² 1993	719	1,354

Source: BBS Census 1981; inventory 1993

Most of the population growth within the banklines, then, occurred in the lower reach, where it increased fourfold between 1981 and 1993. This is associated with the accretion of a large area of charland in what had been the main river channel. These mauzas were largely water in 1984, which explains the low population density of 43 people per km² in 1981. By 1993 the same mauzas had a population density similar to the average for equivalent mauzas in the Meghna. Clearly the area of char land accreted during 1984-93 has not compensated for the area of mainland lost to bank erosion.

Although the population of the within-bankline mauzas almost doubled during 1984-93, the total population is still very low—just over 21,000. The new chars of the lower reach appear to have absorbed some people displaced by bank erosion. In the middle reach the char population has been static, yet more than 50,000 people are estimated to have been displaced by bank erosion. These people cannot have moved into the chars.

The equivalent figures for mainland mauzas not affected by erosion during the period show much higher population growth. Population in these mauzas grew by 38 percent, compared with a 26 percent increase in the national population during 1981-91. In the west bank mainland of the lower reach outside the erosion affected area, on the other hand, there was little increase in population. An increase in population density might have been expected if erosion victims had been crowded into the remaining land on that bank. Perhaps people left this area in anticipation of continued erosion or because of the locally disastrous economic effects of such a large area eroding. Further investigation of erosion impacts in this area is needed. Interestingly, this area comprises the same deltaic sands (Geological Map of Bangladesh, 1990) that were found in the Meghna to have experienced a population decline and which appear to be relatively unproductive and have a low carrying capacity.

Table 4.8 indicates that the study area population has become more concentrated in mainland mauzas that were unaffected by bank erosion between 1984 and 1993. Compared with a 6 percent growth rate in the study area population, growth in the unaffected east bank mauzas was 47 percent, and in the west bank mauzas, 31 percent. In the upper and middle reaches population grew faster in these mauzas than the reach average. In the lower reach population grew in the unaffected mauzas but fell in the reach as a whole.

Since population growth in mainland unaffected by erosion has been higher than the national average, this presumably reflects a shift of people from eroded areas, particularly in the middle and lower reaches, onto the remaining mainland. In 1981 this land had a population density 11 percent higher than the national average of 605 people per km^2, but by 1993 the population density (combining banks) was 930 people per km^2, 22 percent higher than the national average of 1991. This implies that there are about 27,000 more people in these mainland mauzas in 1993 than there would have been had the population grown at the national rate during the 1981-93 period, and 71,000 more than there would have been had the population grown at the study area rate of 6 percent.

4.4.3 Estimated Population Impacts of Erosion

Out of the total 1981 population of the study area about 378,000 people (64 percent) are estimated to have lived on mainland that has not been eroded; population growth at the national average rate would have resulted in about 496,000 people in 1993—the inventory estimate in 1993 was 495,726 people. Likewise, if the population living between the banklines in 1981 continued to grow at the national average the population in 1993 would have been 115,350; 7,600 less than the 1993 inventory figure. Therefore, the evidence of the image analysis, 1981 census, and 1993 inventory suggests that 123,000, or 21 percent of the 1981 population, an amount more or less equivalent to the number estimated to have lived in the area eroded during 1984-93, left the Padma charlands permanently.

4.5 Implications of Analysis

The conclusion that many more people in the middle and lower reaches of the Padma have been affected by erosion than in the upper reach is consistent with the river morphology. The upper reach has a narrow and relatively stable single channel. Using the inventory in combination with satellite image analysis for two years makes reliable aggregate estimates of erosion impacts possible for the first time.

Twenty-one percent of the 1981 population of the Padma charlands is estimated to have been displaced by bank erosion between 1984 and 1993. In the Jamuna River, char-building processes during 1980-92 created land that could accommodate some of the erosion victims, but this has not been the case in the Padma. New chars have emerged, particularly in the lower reach, but the island chars are very dynamic and very little of their 1984 area persisted to 1993. These chars have a low population density and some, which are submerged in the monsoon, are only used for dry season cultivation. If char-building continues then more year-round habitable land may emerge, but at the cost of continued widening of the river and bank erosion of densely populated mainland. The Padma channel is still in a state of change, adjusting to the range of Jamuna flows, so the chars may not stabilize in the way that some Brahmaputra-Jamuna chars have persisted over time, and are unlikely to support a higher population for many years.

A picture of historical erosion impacts could be developed by adding mauza-level population data from earlier censuses, comparative analysis of bankline changes from the 1973 and 1980 Landsat images, and historical maps. With the addition of data from more recent images and short field surveys, the databases could be used as a baseline to monitor continued channel changes and their impacts over time.

Erosion and accretion are not new phenomena along the Padma, but this analysis draws attention to what may become an increasingly tragic human problem as ever more densely populated areas are eroded. The island chars formed within the migrating and widening channel are unable to take up this displaced population. Flood proofing may offer a partial solution for the residents of chars in the middle and lower reaches where flood risk does not preclude settlement. Yet the erosion threat in these areas limits the ability to build flood proof settlements, since the investment is likely to be washed away in a few years.

The future may lie in flood proof embankment settlements that are periodically retired or are protected from erosion and enable residents to commute seasonally to low-lying cultivable chars. Localized stabilization of island chars to increase their longevity, and assistance for communities to stay together and earn a livelihood in the face of flood and erosion risk, could also help.

NOTES

1. Analysis of Variance (ANOVA) indicated that population density was not closely associated with age of land category compared with char land type. This is partly because smaller mauzas tend to have higher population densities.

2. The 1984 image was selected for the analysis because an earlier image might have obscured erosion and accretion between the old image date and the 1993 image.

Chapter 5

CONCLUSIONS AND FUTURE USE OF CHARLAND DATABASE

5.1 Objectives

The aim of the inventory is to provide baseline data for development planning, and particularly, although not exclusively, for planning under the FAP. This report comprises analysis of population, resources, and morphology data of the charlands of the Padma River. Section 5.2 briefly summarizes some of the findings from the inventory. Section 5.3 considers the future uses of the charland GIS and databases, with particular reference to development activities along the Padma. The baseline data in the GIS is available for more localized analysis and planning than was possible for this report.

5.2 Summary of Findings

The study has demonstrated that data can be collected and mapped for the char areas despite the very dynamic nature of their land and population. Conducting a survey of the chars requires up-to-date maps, which are only obtainable by processing satellite images taken two to three months prior to the survey. Otherwise, conditions can change so much that the physical details shown in the maps will have altered (as shown for the Padma in the two images in Figures 2.1 and 2.2). Suitable images normally are available for the annual dry season (December through March). The Charland Study has established a link between cadastral maps of mauza boundaries and digital, image-based maps of land use. These maps can be related to show accurately changes over time relative to mauza boundaries. They also enable mauza-level data, collected from key informants, to be related with maps of land use and channel changes derived from satellite image analysis.

The result is a powerful planning tool that could be refined and updated as the Padma's morphology and population continue to change. Further satellite image analysis covering more than just two years, 1984 and 1993, would help in understanding these dynamics.

Tables 5.1, 5.2, and 5.3 summarize some of the most important inventory data by reach and by land type. As the data show, there are important variations in population and resource bases and in hazards between char types, between reaches, within reaches by char type, and even more localized differences that have been identified by mapping the data. In the Padma charlands, differences between reaches (Table 5.3) are as important for aspects such as flood hazard, as differences between char land types (Table 5.2). While in part this reflects differences between reaches in the composition of land types (for example, there is no inhabited island char land in the upper reach), the three reaches have clearly distinct environments:

- the relatively small upper reach, which has a large area of attached char south of the Ganges-Jamuna-Padma confluence, a single channel, virtually no island chars, and little erosion;
- the middle reach, where two large dynamic island char complexes have emerged in the 10 year period, and the river has

Table 5.1 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 underwater.	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 has been 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 have primary school, lack health facilities. Access difficult.	Worst school provision, and few health facilities.	Relatively good service and infrastructure provision.
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 of mechanized boats.	Availability similar 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 5.2 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 5.3 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 km^2 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.

become wider and somewhat braided; and

- the lower reach, which has had rapid bank erosion accompanying the development of a large meander, and a large island char that has accreted and may soon become an attached char.

This report presents only very aggregated maps; more detailed maps, covering smaller reaches of the Padma, can be produced for specialized uses.

Analysis of Landsat images from 1984 and 1993 revealed that the Padma was very dynamic over the period. The river's activity included the migration, movement, and widening of the channel and a complex changes to the pattern of island chars, which saw islands submerge, erode, and accrete again (Chapter 2). In the context of past alterations in the Padma these changes are moderate and associated with continual adjustment of the river to its present location. In 1767, the Padma did not exist, and only since 1857 has it had its present alignment. In the subsequent period, considerable areas of charland have been created and destroyed. Comparison of the images and historical maps reveals that the narrower reaches of the river near the two confluences have been relatively stable, while the middle reach tends to widen.

The processes of bank erosion and channel changes have been studied through use of a GIS, which allows accurate measurement of changes between historical maps and satellite images. Between 1984 and 1993 there was an overall tendency for the Padma to widen, for the lower reach to move south, and for island chars to be formed and migrate downstream.

Chapters 3 and 4 reveal the consequences of the river's changes: densely populated land is eroded and, to a limited extent, replaced with less densely populated but more hazardous island chars. More than 130,000 people were probably displaced between 1984 and 1993 by aggregate changes in bankline alone; about 93 percent of those people lived in the middle and lower reaches, and virtually all of them are presumed to have left the Padma charlands given the drop in population between 1984 and 1993 in the lower reach. Other things being equal, the trend is likely to continue in the foreseeable future. Few people may be displaced in the upper reach, where there is little erosion, but the meanders in the middle and lower reaches have become more pronounced and so will continue to attack the river banks.

5.3 Future Uses of Padma Charland GIS

5.3.1 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 presents details of the satellite image and inventory analyses for the whole of the Padma, but similar analysis would be possible for smaller planning areas within this study area. The Padma and Meghna databases have been reported separately, but could be combined to investigate the consequences of morphology changes along the Padma and into its confluence with the Meghna. 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 Padma charlands falls between the boundaries of two FAP regional studies. No detailed feasibility studies have so far been proposed for the nearby mainland, but if any projects are proposed in these areas they must address any impacts in adjacent char areas. A number of planned or possible interventions could be users of the Padma charland GIS. Linkages between these interventions and the charland databases and GIS are discussed in the following sub-sections.

5.3.2 Southwest Regional Study (FAP 4)

FAP 4 covers the whole of the west (south) bank of the Padma study area. Embankments already exist along most of this bank of the Padma, and FAP 4 (1993) has proposed completing these structures as far east as the Arial Khan. From this point the control structures and engineering works needed for continual main embankments are regarded as too expensive and risky. Instead, downstream of the Arial Khan, polders outside the active corridor of the Padma have been suggested.

FAP 4 (1993) considered the potential impacts of embankments (see below) and concluded that, although there were likely to be morphological impacts from embankments and that there were risks of erosion, these are not a reason for delaying completion of the embankments. The implications discussed below, however, mean that any such works should include mitigation measures for the charland people who would be affected by increased flood levels. Although the number of people involved and magnitude of impact will be lower than in the charlands adjacent to the Jamalpur Priority Project (FAP 3.1), there are still some 410,000 people living in the Padma charlands upstream of the Arial Khan offtake. These charland people should not be ignored in detailed planning of any future works along the Padma.

5.3.3 North-central Regional Study (FAP 3)

Although a continual embankment along the east (left) bank of the Padma has been proposed under FAP 3, at present the area that would be protected is deeply flooded in normal monsoons, and high river water levels would limit the possibility of improving drainage behind embankments. Hence it was not listed as a high priority in the regional plan. If constructed, embankments on this side of the river would contribute to the same effects discussed under FAP 4, and would require similar compensating measures, perhaps as a joint mitigation project.

5.3.4 Flood Modelling

FAP 25 (1993) has modelled the potential impacts of embankments along the main rivers of Bangladesh. For the Padma the two most relevant scenarios are numbers 3 and 5 in FAP 25 (1993). Table 3.28 reports the predicted increases in flood level, which indicates that confinement of the Jamuna (left and right embankments combined with the Jamuna Bridge) would raise flood levels in a 1988 event by about 20 cm. With embankments along both banks of the Padma as well, the flood level would be about 33 cm above the 1988 level. Even if projects only go ahead on the Jamuna, then, there would be greater flood losses in the Padma charlands. This means that, at least in the Padma, flood proofing and charland development programs should not be linked just to flood control projects in adjacent areas. Instead, they should help char people face the existing flood and erosion risks, and will be needed if upstream interventions go ahead.

FAP 4 (1993) noted that modelling of the above scenarios had some limitations because the south bank flood spill was somewhat crudely modelled, and a fixed-bed model was used. It is thought that relatively small increases in discharge and velocity would result in some channel widening as a consequence of greater confinement of the river. Moreover, increased velocity in the Jamuna downstream of the proposed bridge is likely to result in bed scouring. This may increase sediment conveyance capability, which may mitigate some of the higher flood levels predicted as a result of embankments. Once downstream of the constricted reach of the Jamuna, however, the river's velocity would fall, and with it, the sediment. This additional sediment might well be deposited in the Padma, fueling char formation, braiding, and widening. Chapter 2 has demonstrated that the Padma's planform, and therefore its cross-section, changed markedly between 1984 and 1993. Changes between meandering and braided phases will continue, therefore, flood modelling should make use of a range of past cross-sections and bed levels to represent likely future conditions.

5.3.5 Morphology Studies

The analysis of Chapter 2 has already shown how dynamic the Padma charlands have been in the recent past (1984-1993), and indicated changes over the long term (1767-1984). More detailed analysis of morphological trends and erosion rates is needed, similar to that undertaken by FAP 19 for the Jamuna, using a series of satellite images and relating these with banklines from the historic maps once these have been registered to common coordinates.

Further detailed study of the potential impacts of any proposed works should integrate the satellite image and inventory analysis of FAP 16/19 with modelling of morphological changes. Understanding physical changes and the technical effectiveness of possible protection works are not sufficient to determine and design socially and economically viable interventions. The charland inventory and GIS are the basis for preliminary erosion impact assessment, as well as assessment of the potential social and settlement benefits of bank protection and char stabilization. They could be used as a starting point for more detailed feasibility study and implementation.

5.3.6 Other Flood Proofing Programs

As a follow-up to FAP 23, a variety of pilot flood proofing interventions are being proposed for the Brahmaputra-Jamuna. Flood risks are already high in the Padma charlands, and they are likely to increase as a consequence of proposed interventions in the Jamuna and if further embankments along the Padma are built. Although erosion risk is high in the very dynamic island chars, small-scale flood proofing works should still be considered as a means of counteracting these potential impacts, and of improving the lives of char people—even if flood risks are unchanged.

It is hoped that this report can act as a catalyst to encourage flood proofing and char development programs in the Padma, 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.

5.3.7 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.

5.3.8 NGOs

The inventory found that many mauzas in the Padma charlands are within the programs of NGOs. The inventory shows 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 could use the inventory data to identify priority issues and their locations and extent for planning their programs. NGOs also need information on hazard risks. For example, in the Padma RRA in July 1993 a clinic, built as part of a basic health care program by the Finnish Free Foreign Mission, was visited in North Channel Union in the middle reach. By mid-September it was reported to have been completely lost to erosion along with two primary schools (*Bangladesh Observer*, 1993). Hazard information from the charland GIS might have encouraged moveable construction, which could have prevented the loss of a *pucca* building.

5.4 Longer-Term Institutional Approaches

The riverine charland areas 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 (but not coastal chars), and a national database on these diverse and complex areas is being 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.

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.

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PLATES AND CASE STUDY

INTRODUCTION

The photographs on following pages were taken on 11 and 12 July 1993 during the FAP 16 rapid rural appraisal of the middle reach of the Padma. At that time the Padma was flowing at one of its peaks for the 1993 monsoon season and was just below "danger" level; the level fell on subsequent days. The surveys on these two days covered the mauzas of Diara Gopalpur in Char Bhadrasan Thana (Plates 1, 2, 3, 5, and 7) and Einayatpur in Harirampur Thana (Plates 4, 6, and 8). Diara Gopalpur is on the downstream island char complex and Einayatpur on the upstream complex of this reach of the Padma. During the monsoon both are isolated from the mainland by at least 2 km of river on all sides.

SETTLEMENT PATTERNS

Plates 1 and 2 show parts of the village of Diara Gopalpur. This char emerged most recently after the 1988 floods, but most households have settled from 1991 onwards and the settlement process was continuing in 1993.

In **Plate 1** are two *bhaor* houses. These temporary shelters of catkin grass are used by dry season char farmers who move to their mainland homesteads in the monsoon. There were about 40-50 of these seasonal in-migrant households in this mauza during the winter of 1992-93. Most of them were in the open charland among catkin grass near, but lower than, the main settlement. The land these households cultivate with crops such as groundnuts was deeply flooded by July (some late groundnuts had reportedly been damaged by flooding just as they were to be harvested).

There were about 150 households living permanently in Diara Gopalpur in July 1993, with most of the homesteads arranged more or less in a single line. About 20 percent of the houses were flooded on 11 July 1993.

Plate 2 shows the conditions in most of the other houses: water covered the courtyards and was at or just below floor level. A new primary school and a revenue collection (*tahsil*) office are both located on the edge of the village, but the floor levels were not raised much above 1993 flood level, and were well below 1988 flood level. All of the houses are of catkin grass, but about 10 have corrugated iron roofs as in Plate 2. The majority of the houses are on rented land. Homestead land is rented at fixed rates, while agricultural land is sharecropped. The landowners are mainly businessmen and big landowners who live elsewhere. They lay claim to the land on the basis that it was theirs some 40 years earlier when the land apparently last eroded.

Plate 1 Flooding of Houses Used During Dry Season

Plate 2 Flooded Charland Houses, note Cow Raised on Catkin Grass

Dry land is scarce in the island chars during the monsoon. There is minimal space for kitchen gardens, although several varieties of gourd are grown over houses and trellises.

As shown in **Plate 3**, there are hand tubewells in the island chars, but their use becomes difficult during floods. The inventory found that while 87 percent of island char households use tubewell water in a normal monsoon, in 1988 only 18 percent could drink tubewell water (the highest recorded water level in the Padma, in 1988, was about 1.5 m above the level shown in the plate). Cattle and people are crowded into confined spaces during floods, increasing the hazard of contaminated surface water. The woman visible on the right is washing cooking pots immediately next to the mound where cattle are sheltered.

Plate 4 shows one end of the village of Einayatpur. This char is older and more established than Char Salehpur. One part of the village has been settled continuously for some time. This part of the mauza was settled in about 1957, but after 12 years the land submerged and everyone left for two years. From its reappearance in about 1971 until 1988, it was continually inhabited. The 1988 flood forced all the households to move away again for about three months. Some returned once the flood water receded, and many other households (about 450) have been using the char only in the dry season, returning to temporary shelter on the mainland for the monsoon. As land accretes and persists, more households are settling year-round on the char. In the monsoon there is no agricultural work, and much of the char's economic activity revolves around harvesting the catkin grass that lines the shore and either selling it or using it for fodder. Before 1988 there was a primary school in the village, but now the many children seen here do not have access to a school, the nearest one being a long boat journey away.

Plate 3 Threshold Level Flooding Surrounds a Hand Tubewell

Plate 4 Char Village Surrounded by Flood Water and Catkin Grass

Country boats (**Plate 5**) are the main means of transport for these island char villages throughout the year. In the monsoon, access by boat is possible without walking from the village. In severe floods, boats are essential for saving livestock, property, and lives. Large boats such as this one must be hired to move cattle to the mainland or when houses are in imminent danger of erosion, but the cost is a burden for poor households.

While few households own large country boats, most of the island char households have a small boat like the ones shown in **Plate 6**. A small boat is essential in the monsoon when it is needed even to move within the island chars to collect catkin grass. The catkin grass here is a common resource. Since the large landowners who control these chars do not restrict access to the grass, it has become one of the main sources of income in the monsoon. The other rainy season income source in the chars is fishing, and the boats are used to reach the bamboo traps used to catch fish.

Plate 5 Country Boat in Flooded Village

Plate 6 Abundant Catkin Grass in Charland Village

The scene in **Plate 7** is common to all of the Padma island chars. Everywhere in these char villages there is catkin grass. It is used as fodder for cattle, which remain in the chars but cannot move to graze because of flood water; it is used to build edible platforms to raise cattle above the rising water (note that the stack of straw has a raised base to avoid flood damage); it is used to repair houses (all of those visible have walls of catkin grass stems, and all but one are thatched with catkin grass); and it is taken by boat to mainland markets where it is sold. The grass even form the basis of agriculture, since it traps silt and helps to make newly accreted land cultivable. It was reported in these chars that after three years under catkin grass, recently emerged sandy land should be ready to grow groundnuts.

Plate 8 clearly shows typical char housing construction: the bamboo frame and CI sheets (which few can afford) must be bought from a mainland market, but otherwise the entire construction is from catkin grass obtained from within the chars. Catkin is not the only important plant, however. Banana trees, which provide food, privacy, and shelter for the homestead, are usually planted soon after a household settles on a char. *Dhaincha*, the stems of which can be used for fuel and the leaves for fodder, is often planted along field boundaries. In the plate it is being used to form a barrier against wave action for a house on the edge of the village. The wide expanse of the Padma and monsoon season storms can easily cause waves that raise effective water levels in island chars well above the still water level, increasing damage to houses.

Plate 7 Catkin Grass Harvested by Boat During the Monsoon

Plate 8 Using *Dhaincha* Stems to Protect House from Wave Action

DEPENDENCE ON NATURAL RESOURCES

The scene in **Plate 7** is common to all of the Padma island chars. Everywhere in these char villages there is catkin grass. It is used as fodder for cattle, which remain in the chars but cannot move to graze because of flood water; it is used to build edible platforms to raise cattle above the rising water (note that the stack of straw has a raised base to avoid flood damage); it is used to repair houses (all of those visible have walls of catkin grass stems, and all but one are thatched with catkin grass); and it is taken by boat to mainland markets where it is sold. The grass even form the basis of agriculture, since it traps silt and helps to make newly accreted land cultivable. It was reported in these chars that after three years under catkin grass, recently emerged sandy land should be ready to grow groundnuts.

Plate 8 clearly shows typical char housing construction: the bamboo frame and CI sheets (which few can afford) must be bought from a mainland market, but otherwise the entire construction is from catkin grass obtained from within the chars. Catkin is not the only important plant, however. Banana trees, which provide food, privacy, and shelter for the homestead, are usually planted soon after a household settles on a char. *Dhaincha*, the stems of which can be used for fuel and the leaves for fodder, is often planted along field boundaries. In the plate it is being used to form a barrier against wave action for a house on the edge of the village. The wide expanse of the Padma and monsoon season storms can easily cause waves that raise effective water levels in island chars well above the still water level, increasing damage to houses.

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APPENDIX A

QUESTIONNAIRE FOR THE MEGHNA, PADMA, AND GANGES CHARLAND INVENTORIES

784

Checklist B (6.5.1993)
For primary level investigation

FCODE : |_|_|_|_|_|
Additional code |_|

BANGLADESH FLOOD ACTION PLAN
FAP- 16 ENVIRONMENTAL STUDY

POPULATION AND RESOURCE INVENTORY OF CHAR LANDS IN THE GANGES, PADMA AND MEGHNA RIVER SYSTEMS

MAUZA/VILLAGE KEY INFORMANTS INVENTORY

Name and Identification of Participating Informants

Sl.	Name	Age	Id. code
1			
2			
3			
4			
5			
6			

[Id Codes: 1.Present/Past Chairman/Member 2.Teacher 3.Non-Govt. Officer/Worker 4.Traditional Doctor 5.Imam/Religious Leader 6.Govt Officer/Worker 7.Local Elite 8.Officer/Representative of local club/organisation 9.Other (specify)]

NOTE: THE CODE -9 IS USED WHEN DATA IS MISSING, FOR EXAMPLE WHEN RESPONDENTS ARE UNABLE TO GIVE AN ANSWER OR WHERE A QUESTION WAS NOT ASKED. -8 MEANS NOT APPLICABLE - FOR EXAMPLE NO INHABITANTS SO OCCUPATIONS ARE NOT APPLICABLE. 0 MEANS NONE - FOR EXAMPLE JUTE IS NOT GROWN IN A MAUZA SO 0 AREA. IF A MAUZA IS NOT INHABITED AT THE TIME OF SURVEY THEN SECTIONS A, B, C, E.2, E.3, E.4, E.5 NEED TO BE COMPLETED, PLUS F IF OCCUPIED IN ANY YEAR AFTER 1986, THE OTHER SECTIONS WILL BE "NOT APPLCABLE". YES=1, NO=2.

A. Mauza/Village Identification

CODE

A.1 Mauza Name: ____________________ BBS no: |_|_|_|_|

River no: 1.Meghna 2.Padma 3.Ganges .... |_|_|_|_|

A.2 Name of main village this inventory refers to if mauza is split:

____

A.3 Char Name: ____________________ |_|_|_|_|

A.4 District (Zila): ____________________ |_|_|_|_|

A.5 Thana: ____________________ |_|_|_|_|

A.6 Union: ____________________ |_|_|_|_|

A.7 Distance of centre of mauza/village from nearest mainland: ....miles |_|_|

A.8 Nearest Bank to mauza/village (1.Left; 2.Right) ...... |_|

A.9 Dominant type of land in mauza/village: |_|

1.Island char 2.Attached char 3.Other unprotected land (set back) 4.Submerged (only if whole mauza submerged)

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B. **Physiographic Background of the Land**

B.1 1.Non-Cultivated 2.Cultivated....................... |_|

B.2 1. Inhabited 2. Non-Inhabited:...................... |_|

B.3 Year of last formation of char

[code 0 if mauza/village has 'always' been here]: Year |_|_|_|_|

B.4 Area accreted, if any, in 1991 .... Acres |_|_|_|_|

B.5 Area accreted, if any, in 1992 .... Acres |_|_|_|_|

Since char last formed:

B.6 Year natural vegetation growth started: ....Year |_|_|_|_|

B.7 Year first settled: .... Year |_|_|_|_|

B.8 Year cultivation started: .... Year |_|_|_|_|

Breakdown of total **mauza**:

B.9 What percentage of the **mauza** in the last dry season comprised the following categories? *[see instructions]*
In a normal monsoon at peak water level what percentage of land in each category is flooded/under water?

Char type	% **mauza** area in dry season	% of land flooded in normal monsoon
Island char		
Attached char		
Other unprotected land		
Submerged (under water in dry season)		NA
Total	100 %	NA

[For small areas it may be easier to obtain an estimate in acres, if this is done it must be clearly noted. First column adds to 100% - includes sand as well as vegetated/cultivated land. Second column gives % of land in first column under water in normal monsoon.]

B.10 What was the total area (acres) of land, including sand, in the last dry season in the mauza/village? ....Acres |_|_|_|_|

[rest of this question relates to this area of land]

a % this land under homesteads (including associated trees, ponds and vegetable plots)? ....% |_|_|_|

b % this land not cultivated during year (for example, sand or grazing; additional to homesteads) ....% |_|_|_|

c % this land under rabi/boro cultivation? ....% |_|_|_|

d % this land under kharif I/aus/jute cultivation? .....% |_|_|_|

e % this land under aman cultivation? ....% |_|_|_|

f % this land which is government owned khas land?......% |_|_|_|

g % this land not owned by anyone - common access? .....% |_|_|_|

h % this land owned by people not resident in this mauza/village? ....% |_|_|_|

B.11 Major type of topsoil (% of dry season land area):

1. Sandy (Bele):..% |_|_|_|
2. Sandy-Loam/Silty-Loam (Doas):......................% |_|_|_|
3. Clay (Etel):...% |_|_|_|

B.12 What was the total area (acres) of land (above water) in the last monsoon season in the mauza/village? ....Acres |_|_|_|_|

What percentage was under cultivation? ....% |_|_|_|

B.13 First year erosion occurred :................Year |_|_|_|_|

What was the last year erosion occurred?..........Year |_|_|_|_|

[if never eroded code zero]

B.14 Has all the land in the mauza/village ever been totally submerged by the river for more than one full year?.YES/NO |_|_|

If yes, which year did it last disappear? Year |_|_|_|_|

which year did it last re-appear? Year |_|_|_|_|

B.15 When (if ever) was the land in this mauza/village legally recorded? ....Year |_|_|_|_|

C. <u>Migration, Population and Household Numbers in the Mauza/Village</u>

C.1 Population in the Mauza/Village

- Total number of households: ....nos. |_|_|_|_|_|
- Total population:................................nos. |_|_|_|_|_|

C.2 Migration in last year:

Category	Nos	Area	Reason
Permanent in-migration (hh)			
Permanent out-migration (hh)			
Temprary in-migration (persons)			
Temporary out-migration (persons)			

[Area Code = Main origin (in-migration) or destination (out-migration): 1. Another Island Char 2. Attached Char or Setback Land Left bank 3. Attached Char or Setback Land Right bank 4. Nearby Mainland Left bank 5. Nearby Mainland Right bank 6. Distant Mainland Left bank 7. Distant Mainland Right bank 8. Other (Specify)................
Permanent means that people have no intention of returning
Main Reason Codes: 1.Bank Erosion 2.Char Erosion 3.Flood 4.Seeking Employment 5.Other (Specify).........,]

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C.3 Settlement history of present inhabitants of mauza/village:

What percentage of households in this mauza/village best fit each of the following categories?

Type of Settlers	HH %
Original settler	
Permanent in-migrant	
Sheltered here during flood only (land not washed away and will return next dry season)	
Uthuli sheltered here waiting for land to re-emerge (submerged 1+ years)	
Sheltered here on own or public land waiting for land to re-emerge (submerged 1+ years)	
Uthuli sheltered here after erosion	
Sheltered here on own or public land after erosion	
Total	100 %

[If there are few households involved respondents may find it easier to give a number, calculate percentages of total in C.1 later, these must add to 100%]

C.4 Duration of Settlement
1.Seasonal 2.Temporary 3.Permanent: .... |_|_|

[seasonal=occupied for part of each year (eg. dry season); temporary=occupied for 1 year or more but expect to move; permanent=+1 year and do not expect to move]

Settlement Pattern
1.Nucleated 2.Scattered 3.Clustered 4.Linear 5.Mixed:...... |_|_|

C.5 Housing type in the Mauza/Village:

Main residential housing structures	%
All kutcha (straw, jute sticks, bamboo, grass, leaves etc.)	
Kutcha with tin roof	
All tin (walls and roof)	
Earth wall (kutcha, tile or tin roof)	
Pucca (brick/concrete wall)	
Total houses	100 %

[Where there are few houses of a type the number may be more accurate but then calculate %.]

D. Infrastructure and Services of the Mauza/Village

D.1 Sources used for drinking water in the mauza/village:

Source of water	No.	%hh in monsoon	%hh in peak flood 1988
Tubewell with handpump			
Hand-dug well			
Pond/beel/khal			
River	na		

D.2 How many pucca latrines are there in the mauza/village

..............nos |_|_|_|

D.3 Are any of the following health care facilities available within the mauza/village?
If no, how far to the one which most people use (in each category)? How accessible is it?

Health care facility	Yes/No	Distance	Access
Government Hospital			
Health care centre			
Family planning centre			
NGO health care facility			
Traditional doctor			
Pharmacy			

[Distance: in miles from centre of this mauza/village
Access: 1 land access throughout year, 2 boat journey needed throughout year, 3 boat journey in monsoon only]

D.4 Communications and Institutions in the Mauza/Village

1. Road length:
   - Brick/Paved: ....km |_|_|_|
   - Earthen:.......................................km |_|_|_|
   - Cart track (Halot):............................km |_|_|_|
2. Flood Embankments Length: ....km |_|_|_|
3. Launch Ghats:....................................Nos |_|_|
4. Kheya Ghats:.....................................Nos |_|_|
5. Number of motorised boats based here:............Nos |_|_|
6. Number of non-motorised boats:...................Nos |_|_|_|
7. Electricity available........................YES/NO |_|_|
7. Telephones:......................................Nos |_|_|
8. Radios:..Nos |_|_|_|
9. Televisions:.....................................Nos |_|_|_|
10. Number of Banks:................................Nos |_|_|
11. Number of NGOs working in Mauza/Village:........Nos |_|_|
12. Names of NGO's ______________________________

____

D.5 Education Institutions
How many of the following are there in the mauza/village?
If none, how far to the one most used by children from the mauza/village?
How accessible is it?

Education facility	No.	Distance	Access
Primary School			
Junior High School (upto class VIII)			
High School			
Madrashas			
Colleges			

[Distance: in miles from centre of this mauza/village
Access: 1 land access throughout year, 2 boat journey needed throughout year, 3 boat journey in monsoon only]

D.6 How many markets of the following kinds are there in the mauza/village?
If none, how far to the one most used by people of this mauza/village?
How accessible is it?

Market type	No.	Distance	Access
Hat			
Bazar			
Major bazar			
Independent shops			
Ferrywallas		NA	NA

[Distance: in miles from centre of this mauza/village
Access: 1 land access throughout year, 2 boat journey needed throughout year, 3 boat journey in monsoon only]

D.7 Date the Mauza/Village was last visited by Government Institutional personnel:

Institutions	Year	Month
Agricultural Extension Officer		
Police Officer		
Health Worker		
Social Welfare Officer		
Veterinary Officer		
Family Welfare Visitor		
NGO Representative		
Others ____________		

[Code 0 if never visited by that official]

D.8 Does your UP Chairman live in this mauza? ....YES/NO |_|_|
If no, does he live in this Union? ....YES/NO |_|_|

E Socio-Economic and Agricultural Conditions

E.1 What are the main sources of household livelihood in the Mauza/Village?

Main Occupation	% of HHs with Primary source	% of HHs with Secondary source
Cultivating (own or sharecrop land)		
Fishing		
Agricultural labouring		
Non-agricultural labouring		
Transport		
Petty business (daily basis)		
Larger business		
Service		
Paid household work		
Remittances from outside		
Others (specify)		
No livelihood generating activity		
Total	100 %	NA

[Note: main occupation percentages should sum to 100%]

E.2 Cropping Intensity: what percentage of last year's cultivated area of the mauza/village is...
[Actual area may be noted if very small, but calculate % later]

Cropping Intensity	% cultivated area
Single cropped	
Double cropped	
Triple cropped	

E.3 Agricultural Production

What percentage of the cultivated area last year was under each crop? Typically in a normal year what is the average yield? How many times (if any) has this crop been damaged by flood in the last five years (1988-1992)?

Crop	% of cultivated area	average yield (md/acre)	no years in last 5 damaged by flood
Kaun/china			
Ground nut			
Pulses			
Onion			
Til			
Chilies			
Wheat			
Potatoes			
Sweet Potatoes			
Mustard			
Local Boro			
HYV Boro			
Aus paddy			
Jute			
B. Aman			
T. L. Aman			
HYV Aman			
Sugarcane			
Dhaincha			
Catkin grass			
Others (Specify)			

[For crops covering small areas actual acreages may be easier for respondents to estimate in which case the % of cultivated area should be calculated based on the area given in B.10]

E.4 Livestock and Poultry - Estimated Numbers in Mauza/Village

Type	No. in dry season	No. in monsoon
Cattle		
Buffalo		
Goat/sheep		
Chickens/ducks		
Others (specify)		

E.5 Are any of the following tree types present in the mauza/village?

Banana ....YES/NO |_|_|
Babla ....YES/NO |_|_|
Bamboo ....YES/NO |_|_|
Boroi ....YES/NO |_|_|
Mango ....YES/NO |_|_|
Jackfruit ....YES/NO |_|_|

F <u>Hazard Occurrence and Losses</u>

F.1 How was the mauza/village affected by floods in the last six years?

Year	% cultivable land flooded	duration (days)	% houses not flooded	% houses flooded > floor and < roof	% houses flooded above roof	% houses destroyed	No human lives lost
1992							
1991							
1990							
1989							
1988							
1987							

[% of land is of land which was or could have been cultivated in the preceding year (dry season or monsoon), but was under water at peak flood time in that year. Duration also applies to peak flood time.]

F.2 How was the mauza/village affected by erosion in the last six years?

Year	Area lost to erosion (acres)	No. homestead plots lost	No. human lives lost
1992			
1991			
1990			
1989			
1988			
1987			

F.3 How many times (if any) have the following occurred in the mauza/village in the last 5 years? What has been the most important loss? Were there any human deaths? (how many?)

Hazard	No. of occasions	Main loss	Total No. human deaths
Severe storm (with high wind eg tornado)			
Hailstorm			
Drought			
Sand carpeting			
Famine			
Epidemic			
Other (specify)			

[Loss/damage codes: 1.Crop 2.Housing 3.Large/small Livestock 4.Infrastructure (Roads/Buildings) 5.Poultry 6.Human Death 7.Other (Specify)]

G Land settlement and rights

G.1 When land has emerged in this mauza/village (if applicable) have there been problems or disputes over its allocation? (for example cases where the salish is involved, or where cases are registered)
1.Never 2.Up to one a year on average 3.A few in a year 4.Many |_|_|

If yes, were any of the parties involved resident outside the mauza? ....YES/NO |_|_|

Has violence ever been used in land disputes?........YES/NO |_|_|

If yes, were there any deaths?......................YES/NO |_|_|

ADDITIONAL COMMENTS BY ENUMERATOR ON ANY SPECIAL ISSUES IN THE MAUZA/VILLAGE WHICH ARE NOT COVERED IN THE QUESTIONNAIRE:

Signature of Supervisor
Date: ....

Signature of Enumerator
Date:..................

CODING AND INTERVIEW INSTRUCTIONS:

MAUZA OR VILLAGE?

IF THE MAUZA IS SPLIT WITH ONE OR MORE VILLAGES IN EACH OF TWO PHYSICALLY SEPARATED CHARLAND TYPES YOU MUST FILL OUT A QUESTIONNAIRE FOR EACH PART OF THE MAUZA. FOR EXAMPLE, MAUZA CONTAINS PART OF AN ISLAND CHAR WITH VILLAGE AND AN ATTACHED CHAR WITH TWO VILLAGES, THEN COMPLETE AN INVENTORY FOR THE ISLAND CHAR VILLAGE AND ANOTHER FOR THE ATTACHED CHAR. ALSO SPLIT A MAUZA IF YOU CANNOT FIND RESPONDENTS WHO ARE ABLE TO GIVE A CONSENSUS OF DATA REPRESENTING THE WHOLE MAUZA - FOR EXAMPLE A VERY LARGE MAUZA WITH MANY VILLAGES. IN SUCH CASES YOU SHOULD REFER TO THE VILLAGE(S) WHEREVER THE QUESTIONNAIRE REFERS TO MAUZA, AND MARK ITS BOUNDARY ON THE MAP.

LOCATE MAUZA/VILLAGE ON THE BASE IMAGE, IF THE MAUZA IS SPLIT MARK THE APPROXIMATE ACTUAL BOUNDARIES OF EACH PART OF THE MAUZA WITH A SEPARATE INVENTORY. LIKEWISE IF YOU FIND THE MAUZA ACCORDING TO RESPONDENTS IS IN A DIFFERENT LOCATION OR HAS CLEARLY DIFFERENT BOUNDARIES FROM THOSE ON THE IMAGE PROVIDED, THEN MARK THE BOUNDARIES FOUND IN THE FIELD WHERE THESE DIFFER FROM THOSE ON THE BASE IMAGE, WRITE IN THE NAME OF THE VILLAGE IF A SPLIT MAUZA.

CODES

THE CODE -9 (MINUS NINE) IS USED WHEN DATA IS MISSING, FOR EXAMPLE WHEN RESPONDENTS ARE UNABLE TO GIVE AN ANSWER OR WHERE A QUESTION WAS NOT ASKED. THE CODE -8 MEANS (MINUS EIGHT) NOT APPLICABLE - FOR EXAMPLE NO INHABITANTS SO OCCUPATIONS ARE NOT APPLICABLE. 0 MEANS NONE - FOR EXAMPLE JUTE IS NOT GROWN IN A MAUZA SO 0 AREA. IF A MAUZA IS NOT INHABITED AT THE TIME OF SURVEY SECTIONS A, B, C, E.2, E.3, E.4, E.5 NEED TO BE COMPLETED, PLUS F IF OCCUPIED IN ANY YEAR AFTER 1986, THE OTHER SECTIONS ARE "NOT APPLICABLE".

IN YES/NO QUESTIONS CODES AREA: YES=1, NO=2.

DASHES "-" ARE NOT ACCEPTABLE, USE 0 FOR A NUMBER ZERO (ZERO ACRES, ZERO PERCENT ETC), OR -8 IF NOT APPLICABLE ETC.

যাচাইপত্র–'খ'   ৮ মে, ১৯৯৩ ইং   এফ কোড : [ ][ ][ ][ ][ ][ ][ ][ ][ ][ ]

প্রাথমিক স্তরের জরীপের জন্য   সংযুক্ত ক্রম : [ ]

বাংলাদেশ ফ্লাড এ্যাকশন প্লান

(বাংলাদেশ বন্যা নিয়ন্ত্রণে কার্যকর পরিকল্পনা)

ফ্যাপ–১৬ পরিবেশ স্টাডি

পপুলেশন এ্যান্ড রিসোর্স ইনভেন্টরী অব চরল্যান্ডস্ ইন দ্য গঙ্গা/পদ্মা/মেঘনা রিভার সিস্টেমস্

(গঙ্গা/পদ্মা/মেঘনা নদীর অন্তর্ভূক্ত চরসমূহের জনসংখ্যা ও সম্পদসমূহের জরীপ)

অংশগ্রহণকারী তথ্যদাতাদের নাম ও পরিচয়

ক্রমিক নং	নাম	বয়স	পরিচয় কোড
১.			
২.			
৩.			
৪.			
৫.			
৬.			

পরিচয় কোড : ১: ইউনিয়ন পরিষদের বর্তমান/সাবেক চেয়ারম্যান, সদস্য/সদস্যা; ২: শিক্ষক; ৩: বেসরকারী প্রতিষ্ঠানের কর্মকর্তা/কর্মী; ৪: স্থানীয় সনাতনী চিকিৎসক; ৫: মসজিদের ইমাম/ধর্মীয় নেতা; ৬: সরকারী কর্মকর্তা/কর্মচারী; ৭: এলাকার প্রবীন ব্যক্তিবৃন্দ; ৮: স্থানীয় ক্লাব/সংস্থার কর্মকর্তা/প্রতিনিধি; ৯: অন্যান্য (উল্লেখ করুন)।

নোট : যেসব ক্ষেত্রে তথ্য "পাওয়া যাবে না" সেসব ক্ষেত্রে কোড নং '–১' ব্যবহার করুন। উদাহরণ: যদি উত্তরদাতারা কোন প্রশ্নের উত্তরদানে অক্ষম হন অথবা কোন প্রশ্ন জিজ্ঞাসা করা না হয়। প্রযোজ্য নয়। এসব ক্ষেত্রে কোড নং '–৮' ব্যবহার করুন। উদাহরণ: যে চরে বসতি নেই সে চরে পেশা সংক্রান্ত প্রশ্ন প্রযোজ্য নয়। যে প্রশ্নের উত্তরে "নাই" হবে সে ক্ষেত্রে কোড "০" হবে। উদাহরণ: কোন মৌজায় যদি পাট না হয় তবে পাটচাষের জমির পরিমাণ "০" হবে। জরীপ কার্য চলার সময় যদি কোন মৌজা জনবসতিপূর্ণ না হয় সে ক্ষেত্রে শুধুমাত্র সেকশন ক, খ, গ, ঙ২, ঙ৩, ঙ৪, ঙ৫ সমূহ পূরণ করতে হবে। সেই সাথে যদি ১৯৮৬ সালের পর যে কোন বৎসর বসতি থেকে থাকে তবে সেকশন 'চ' অতিরিক্ত পূরণ করতে হবে। বাকী প্রশ্নগুলো প্রযোজ্য নয় '–৮' হবে। উত্তর হাঁ বা না হলে : হাঁ = ১ ও না = ২

কোড

ক. মৌজা/গ্রাম পরিচিতি :

ক.১ মৌজার নাম : ____________________ নদী নং [ ]

নদী কোড নং : ১: মেঘনা; ২: পদ্মা; ৩. গঙ্গা   বি, বি, এস নং [ ][ ][ ][ ]

ক.২ গ্রামের নাম : ____________________

যদি মৌজাটিতে একাধিক গ্রাম থাকে

ক.৩ চরের নাম : ____________________

ক.৪ জিলা : ____________________

ক.৫ থানা : ____________________

ক.৬ ইউনিয়ন : ____________________

ক.৭ মৌজা বা গ্রামের কেন্দ্র থেকে নিকটতম মূলভূমির দূরত্ব : __________ মাইল

ক.৮ মৌজা/গ্রামের নিকটতম নদী তীর কোন দিকে (১ বাম/২ ডান)

ক.৯ মৌজা বা গ্রামটি প্রধানতঃ কোন ধরনের : ____________________

মৌজা ধরন : ১: দ্বীপ চর, ২: সংলগ্ন চর, ৩: অন্যান্য অরক্ষিত ভূমি (সেটব্যাক), ৪: ডুবন্ত মৌজা (যদি সম্পূর্ণ মৌজা ডুবন্ত থাকে)

কোড

চর ভূমির গঠন ও প্রকৃতিগত প্রেক্ষাপট

খ.১ ১. অনাবাদী; ২. আবাদী

খ.২ ১. জনবসতীপূর্ণ, ২. জনবসতিহীন

খ.৩ এই চর কোন্ সালে সর্বশেষ জেগে ওঠে ______________________ বৎসর
(মৌজা/গ্রামটির অবস্থান যদি সবসময় থেকে থাকে তবে কোড্ '০' দিন)

খ.৪ যদি ভূমি জেগে থাকে, ১৯৯১ ইংরেজী বছরে জেগে ওঠা এলাকার পরিমাণ________ একর

খ.৫ যদি ভূমি জেগে থাকে, ১৯৯২ ইংরেজী বছরে জেগে ওঠা এলাকার পরিমাণ________ একর

শেষবার চর জেগে ওঠার পর :

খ.৬ কোন সালে প্রথম প্রকৃতিগতভাবে ঘাস-পালা জন্মায়। ______________________ সাল

খ.৭ বসতি স্থাপন কোন্ সালে শুরু হয়। ______________________ সাল

খ.৮ প্রথম চাষাবাদ কোন্ সালে শুরু হয়। ______________________ সাল

সম্পূর্ণ মৌজা (পরিসংখ্যানগত বিশ্লেষণ)

খ.৯ গত শুষ্ক মৌসুমে মৌজার কত অংশ কোন ধরনের চরের অন্তর্ভুক্ত হয়। *(নির্দেশ দেখুন)*
সাধারণ বর্ষায় নিম্নবর্ণিত জমির কত অংশ পানিতে নিমজ্জিত থাকে।

চরের ধরণ	শুষ্ক সময়ে মৌজা এলাকার অংশ (%)	সাধারণ বন্যার সর্বোচ্চ পানির সময় ঐ সারির শতকরা কতভাগ জলমগ্ন থাকে (%)
দ্বীপ চর		
নদী তীর সংলগ্ন চর		
অন্যান্য অরক্ষিত ভূমি (সেটব্যাক)		
নদীতে নিমজ্জিত (শুষ্ক মৌসুমে জলমগ্ন)		প্রযোজ্য নয়
সর্বমোট	১০০%	প্রযোজ্য নয়

(মোট জায়গার বেলায় একরে পরিমাণ নির্ণয় সহজ হইবে, যদি তাই করা হয় তবে তা পরিষ্কারভাবে লিখতে হবে)। প্রথম কলামের যোগ ১০০% হবে। এখানে বালুময়, ঘাসাচ্ছাদিত, চাষকৃত ভূমি অন্তর্ভুক্ত হবে। দ্বিতীয় কলামের প্রতিটি সারি প্রথম কলামের সারির শতকরা কত অংশ স্বাভাবিক বর্ষায় পানিতে নিমজ্জিত থাকে।

খ.১০ গত শুষ্ক মৌসুমে বালুময় এলাকাসহ মৌজা/গ্রামের মোট জমির পরিমাণ কত একর ছিল !
(পরবর্তী প্রশ্নসমূহ উপরোল্লিখিত ভূমি সংক্রান্ত)

অ- খ.১০ এর শতকরা কত অংশ বসতবাড়ী (গাছপালা, পুকুর সব্জীবাগানসহ) ! %

আ- খ.১০ এর শতকরা কতঅংশ জমিতে গত বৎসর কোন চাষাবাদ হয়নি। (উদাহরণস্বরূপ বসতবাটিসহ বালু বা গোচারণ ভূমি) %

ই- খ.১০ এর শতকরা কত অংশে রবিশস্য/বোরো চাষ করা হয়েছে ! %

ঈ- খ.১০ এর শতকরা কত অংশে খরিফ-১ আউশ/পাট চাষ করা হয়েছে ! %

উ- খ.১০ এর শতকরা কত অংশে আমন চাষ করা হয়েছে ! %

ঊ- খ.১০ এর শতকরা কত অংশ সরকারের খাস জমি ! %

ঋ- খ.১০ এর শতকরা কত অংশ (জনগণের সাধারণ ব্যবহার্য) ব্যক্তিমালিকানাধীন নয় ! %

এ- খ.১০ এর শতকরা কত অংশ এই মৌজা/গ্রামের বাসিন্দার মালিকানাধীন নয় ! %

খ.১১ উপরিভাগের মৃত্তিকার ধরন (শুষ্ক মৌসুমের শতকরা কতভাগ জমি) !

১. বেলে %

২. বেলে-দোআঁশ/দোআঁশ %

৩. এঁটেল %

খ.১২ গত বর্ষায় মৌজা/গ্রামের মোট কত একর জমি প্লাবনমুক্ত ছিল। একর
ঐ জমির কত অংশে চাষাবাদ হয়েছে। %

১৩ প্রথম কোন বৎসর মৌজায় নদী ভাঙ্গন ঘটেছে | সাল

সর্বশেষ কোন্ সালে নদীভাঙ্গন ঘটেছে | সাল

(যদি কখনোই ভাঙ্গন না ঘটে থাকে তবে কোড ৫ দিন)

খ.১৪ কখনও কি একটা পুরো বছরের চেয়েও বেশী সময় ধরে মৌজা/গ্রামের সমস্ত জমি নদীতে তলিয়ে ছিলো? | হ্যাঁ / না

১৪.১ যদি 'হ্যাঁ' হয়, তবে সর্বশেষ কোন্ সালে তা পুরোপুরি তলিয়েছিল? | সাল

১৪.২ সর্বশেষ কোন্ সালে ঐ জমি পুনরায় জেগে ওঠে? | সাল

খ.১৫ কোন সালে মৌজা/গ্রামটি সরকারের নথিভূক্ত/রেকর্ড হয় (যদি হয়ে থাকে) | সাল

গ. মৌজা/গ্রাম এর জনস্থানান্তর, জনসংখ্যা ও খানার সংখ্যা

গ.১ মৌজা/গ্রামের জনসংখ্যা

– মোট খানার সংখ্যা | টা

– মোট জনসংখ্যা | জন

গ.২ গত এক বৎসরে জনস্থানান্তর :

ধরণ	সংখ্যা	এলাকা	কারণ
স্থায়ীভাবে আগমন (খানা)			
স্থায়ীভাবে নির্গমন (খানা)			
সাময়িকভাবে আগমন (ব্যক্তি)			
সাময়িকভাবে নির্গমন (ব্যক্তি)			

এলাকা কোড : *প্রধান এলাকা (আগমন) বা গন্তব্যস্থল (নির্গমনের জন্য)*

১: অন্য বালুচর; ২: বাঁ তীর সংলগ্ন চর বা 'সেটব্যাক' ভূমি; ৩: ডান তীর সংলগ্ন চর বা 'সেটব্যাক' ভূমি; ৪: বাঁ তীর নিকটবর্তী মূলভূমি; ৫: ডান তীর নিকটবর্তী মূলভূমি; ৬: বাঁ তীর দূরবর্তী মূলভূমি; ৭: ডান তীর দূরবর্তী মূলভূমি; ৮: অন্যান্য (নির্দিষ্ট করে লিখুন)

(উপরে স্থায়ী বলতে তার কখনও ফেরার ইচ্ছে নেই বোঝানো হচ্ছে)

প্রধান কারণ : ১: নদীতীর ভাঙ্গন; ২: চর ভাঙ্গন; ৩: বন্যা; ৪: কর্মসংস্থানের খোঁজে; ৫: অন্যান্য (নির্দিষ্ট করে লিখুন)

গ.৩ মৌজা/গ্রামের বর্তমান বাসিন্দাদের বসতি স্থাপনের ইতিবৃত্ত :

(নিচে বর্ণিত বসতির ধরন অনুযায়ী প্রযোজ্য খানাসমূহ শতকরা হারে লিখুন)

বসতির ধরণ	খানার %
আদি বসতি	
স্থায়ীভাবে আগত	
শুধুমাত্র বন্যার সময় আশ্রয়গ্রহণকারী (জমি ভেঙ্গে যায়নি পরবর্তী শুষ্ক মৌসুমে ফিরে যাবে)	
উঠুলি, জমি পুনঃজেগে উঠার অপেক্ষায় এখানে আশ্রয় নিয়েছে (ভূমি বৎসরাধিককাল যাবত ডুবে আছে)	
জমি পুনঃজেগে উঠার অপেক্ষায় এখানে নিজ অথবা খাস জমিতে আশ্রয় নিয়েছে (ভূমি বৎসরাধিককাল যাবত ডুবে আছে)	
উঠুলি, নদী ভাঙ্গনের পর এখানে আশ্রয় নিয়েছে	
নদী ভাঙ্গনের পর এখানে নিজ অথবা খাস জমিতে আশ্রয় নিয়েছে	
মোট	১০০ %

খানার সংখ্যা অল্প হলে উত্তরদাতার পক্ষে সংখ্যা বলা সহজ হবে। গ.১ কে মোট ধরে এইসব সংখ্যার শতকরা হার বের করে লিখুন। এই শতকরা হারের যোগফল অবশ্যই ১০০% হবে।

১৮০

কোড

গ.৪ বসতি স্থাপনের কাল ঃ

১. সাময়িক	২. অস্থায়ী	৩. স্থায়ী

সংজ্ঞা ঃ
সাময়িক– প্রতি বৎসরের কিছু সময়কাল/নির্দিষ্ট সময়কাল অবস্থান করেন (ঋতু সময়ে)
অস্থায়ী– এক বৎসর বা ততোধিককাল আছেন কিন্তু চলে যাবার আশা করেন
স্থায়ী– এক বৎসর বা তার অধিককাল ধরে আছেন এবং চিরস্থায়ীভাবে বসবাসের আশা করেন

বসতি বিন্যাসের ধরন ঃ

১. কেন্দ্রিক	২. ছড়ানো–ছিটানো	৩. গুচ্ছধরনের	৪. সরলরৈখিক	৫. মিশ্র

গ.৫ মৌজা/গ্রামের ঘরবাড়ির ধরন ঃ

প্রধান আবাসিক ঘর–বাড়ির কাঠামো	%
কাঁচা ঘর (খড়, পাটখড়ি, বাঁশ, ছনপাতা ইত্যাদি)	
কাঁচা ঘর (টিনের চাল)	
সম্পূর্ণ টিনের ঘর (বেড়া ও চালসহ)	
মাটির দেয়াল ঘর (কাঁচা অথবা টিনের চাল/টাইল)	
পাকা (ইট/কংক্রিট দেয়াল)	
মোট ঘর	১০০%

(যেখানে ঘরের সংখ্যা কম সেখানে সরাসরি সংখ্যা থেকে হিসেব করে শতকরা হারে লিখুন।)

ঘ. অবকাঠামো এবং সুযোগসুবিধা (মৌজা/গ্রামে) ঃ

ঘ.১ খাবার পানির উৎস

পানির উৎস	সংখ্যা	% খানা বর্ষাকালে	% খানা ১৯৮৮'র সর্বোচ্চ বন্যায়
১. হাতলযুক্ত নলকূপ			
২. খননকৃত কূয়া			
৩. ডোবা/বিল/পুকুর			
৪. নদী	প্রযোজ্য নয়		

ঘ.২ মৌজায়/গ্রামে কতগুলি পাকা পায়খানা আছে। সংখ্যা ________________ টা

ঘ.৩ নিম্নবর্ণিত স্বাস্থ্য সুবিধাদি এই মৌজা/গ্রামে আছে কিনা। যদি না থাকে অধিকাংশ মৌজা/গ্রামবাসীগণ স্বাস্থ্যসুবিধা যেখান থেকে পান সেটা কতদূর। কিভাবে সেখানে যাতায়াত করেন, প্রত্যেক প্রকারের দূরত্ব ও যাতায়াতের ধরণ লিখুন ঃ

স্বাস্থ্য সুবিধা	হাঁ/না	দূরত্ব	যাতায়াতের ব্যবস্থা
১. সরকারী হাসপাতাল			
২. স্বাস্থ্য কেন্দ্র			
৩. পরিবার পরিকল্পনা কেন্দ্র			
৪. এনজিও স্বাস্থ্য রক্ষা সুবিধা			
৫. সনাতন চিকিৎসক			
৬. ঔষধের দোকান			

নির্দেশিকা ঃ
দূরত্ব – মৌজার কেন্দ্র থেকে দূরত্ব মাইলে লিখুন, ভগ্নাংশের ক্ষেত্রে দশমিক ব্যবহার করুন (যেমন: আধামাইল = .৫০ বা সিকিমাইল = .২৫)
যাতায়াত– ১: সারা বৎসর স্থলপথ; ২: সারা বৎসর নৌকায়; ৩: শুধুমাত্র বর্ষাকালে নৌকায়

কোড

ঘ.৪ মৌজা/গ্রামে যোগাযোগ ও প্রতিষ্ঠান ঃ

১. মৌজা/গ্রামে রাস্তার দৈর্ঘ
- ইট বিছানো রাস্তা/পাকা রাস্তা ______ মাইল
- মাটির রাস্তা ______ মাইল
- হাল্ট/গরু/মহিষের গাড়ী যাতায়াত রাস্তা ______ মাইল

২. বন্যা নিয়ন্ত্রণ বাঁধ ______ মাইল

৩. লঞ্চঘাট (সংখ্যা) ______ টি

৪. খেয়া ঘাট (সংখ্যা) ______ টি

৫. মৌজায়/গ্রামে যন্ত্রচালিত নৌকার সংখ্যা ______ টি

৬. মৌজায়/গ্রামে নৌকার সংখ্যা (যন্ত্রচালিত নয়) ______ টি

৭. বিদ্যুৎ ব্যবস্থা আছে কিনা ______ হ্যাঁ / না

৮. টেলিফোন (সংখ্যা) ______ টি

৯. রেডিও (সংখ্যা) ______ টি

১০. টেলিভিশন (সংখ্যা) ______ টি

১১. ব্যাংক (সংখ্যা) ______ টি

১২. মৌজা/গ্রামে কর্মরত এনজিও (সংখ্যা) ______ টি

১৩. এনজিও'দের নাম ______

______

______

ঘ.৫ শিক্ষা প্রতিষ্ঠানসমূহ

(নিম্নবর্ণিত প্রতিষ্ঠানসমূহের কয়টি মৌজা/গ্রামে/চরে বিদ্যমান। যদি এগুলির একটিও মৌজা/গ্রামে/চরে না থাকে তবে মৌজা/গ্রামের/চরের বেশীরভাগ ছেলেমেয়েরা যে প্রতিষ্ঠান ব্যবহার করে সেই প্রতিষ্ঠান/প্রতিষ্ঠানসমূহ কতদূরে এবং যাতায়াতের ব্যবস্থা লিখুন।)

শিক্ষা ব্যবস্থা সুবিধা	সংখ্যা	দূরত্ব	যাতায়াত ব্যবস্থা
১. প্রাথমিক বিদ্যালয় (সংখ্যা)			
২. জুনিয়র বিদ্যালয় (৮ম শ্রেণী পর্যন্ত)			
৩. উচ্চ বিদ্যালয়			
৪. মাদ্রাসা			
৫. কলেজ			

নির্দেশিকা ঃ দূরত্ব = মৌজার কেন্দ্র থেকে দূরত্ব মাইলে লিখুন, ভগ্নাংশের ক্ষেত্রে দশমিক ব্যবহার করুন (যেমনঃ আধামাইল = .৫০ বা সিকিমাইল = .২৫)

যাতায়াত = ১: সারা বৎসর স্থলপথে; ২: সারা বৎসর নৌকায়; ৩: শুধুমাত্র বর্ষাকালে নৌকায়

কোড

মৌজা/গ্রামে হাট–বাজার

(নিম্নবর্ণিত হাটবাজারগুলির মধ্যে কয়টি মৌজা/গ্রামে আছে। যদি এগুলির একটিও মৌজা/গ্রামে না থাকে তবে মৌজা/গ্রামের বেশীরভাগ লোকজন যে হাটবাজারে যায় সেই সমস্ত হাটবাজার কতদূরে এবং যাতায়াতের ব্যবস্থা লিখুন।)

হাটবাজারের প্রকার	সংখ্যা	দূরত্ব	যাতায়াত ব্যবস্থা
১. হাট			
২. বাজার			
৩. বড় বাজার			
৪. দোকান (ব্যক্তি মালিকানাধীন)			
৫. ফেরীওয়ালা		প্রযোজ্য নয়	প্রযোজ্য নয়

নির্দেশিকা। দূরত্ব – মৌজার কেন্দ্র থেকে দূরত্ব মাইলে লিখুন, ভগ্নাংশের ক্ষেত্রে দশমিক ব্যবহার করুন (যেমন: আধামাইল = .৫০ বা সিকিমাইল = .২৫)
যাতায়াত– ১: সারা বৎসর স্থলপথ, ২: সারা বৎসর নৌকায়, ৩: শুধুমাত্র বর্ষাকালে নৌকায়

ঘ.৭ সরকারী প্রাতিষ্ঠানিক দায়িত্ববান ব্যক্তি সর্বশেষ কবে গ্রাম/মৌজায় এসেছেন

প্রতিষ্ঠান	সাল	মাস
কৃষি সম্প্রসারণ কর্মকর্তা/কর্মী		
পুলিশ কর্মকর্তা		
স্বাস্থ্য কর্মী		
সমাজসেবা কর্মকর্তা		
পশুপালন কর্মকর্তা		
পরিবার কল্যাণ পরিদর্শক		
এনজিও প্রতিনিধি		
অন্যান্য		
১. ______		

নির্দেশিকা। যদি কখনও পরিদর্শনে কোন কর্মকর্তা/কর্মী না এসে থাকে '০' কোড দিন।

ঘ.৮ ইউনিয়ন পরিষদের চেয়ারম্যান এই মৌজাতে বসবাস করেন কি। হ্যাঁ / না

যদি 'না' হয়, তবে তিনি কি এই ইউনিয়নে বাস করেন। হ্যাঁ / না

কোড

৬. আর্থ–সামাজিক এবং কৃষি বিষয়ক অবস্থা

৬.১ মৌজা/গ্রামের খানাসমূহের জীবনধারনের প্রধান অবলম্বন/উপায়সমূহ কি?

মুখ্য পেশা	শতকরা কতভাগ খানার আয়ের প্রধান উৎস	শতকরা কতভাগ খানার আয়ের গৌণ উৎস
১. কৃষি (নিজস্ব অথবা বর্গা জমি)		
২. মৎস্য		
৩. দিন মজুর (কৃষি)		
৪. দিন মজুর (অকৃষি)		
৫. পরিবহণ		
৬. ক্ষুদ্র ব্যবসায় (দৈনিক ভিত্তিক)		
৭. বড় ব্যবসায়		
৮. চাকুরী		
৯. গৃহস্থালী কাজ (অর্থের বিনিময়ে)		
১০. বাহির থেকে প্রেরিত অর্থ		
১১. অন্যান্য (উল্লেখ করুন)		
১২. জীবিকা নির্বাহের উপযোগী কোন আয় নাই		
মোট	১০০ %	প্রযোজ্য নয়

(বিঃদ্রঃ প্রধান পেশার যোগফল ১০০% হইবে)

৬.২ ফসলের নিবিড়তা ঃ মৌজা/গ্রামে গত বৎসরের চাষকৃত জমির শতকরা কত অংশ নিম্নোল্লেখিত ধরনের অন্তর্ভূক্ত ছিল।

নির্দেশিকা– *(জমির পরিমাণ কম হলে যথার্থ সংখ্যা একত্রে যোগ করে তারপর শতকরা হারে হিসাব করে দিন)*

ফসলের নিবিড়তা	চাষকৃত জমির %
১. এক–ফসলী	
২. দো–ফসলী	
৩. তিন–ফসলী	

৬.৩ কৃষি উৎপাদন

গত বৎসর প্রতি ফসলের জন্য ব্যবহৃত জমির শতকরা পরিমাণ কত? সাধারণতঃ প্রাকৃতিক দুর্যোগমুক্ত বৎসরের গড় ফলন কত? গত ৫ (পাঁচ) বৎসরে (১৯৮৮–৯২) যদি ফসলের ক্ষতি হয়ে থাকে তবে কতবার?

ফসল	গত বছর চাষকৃত জমির শতকরা হার (%)	গড় ফলন (মণ/একর)	গত ৫ বৎসরে (১৯৮৮ – ৯২) বন্যায় কত বছর ফসল ক্ষতিগ্রস্ত হয়েছে
১. কাউন/চিনা			
২. চীনাবাদাম			
৩. ডাল			
৪. পেঁয়াজ			
৫. তিল			
৬. মরিচ			
৭. গম			
৮. গোল আলু			
৯. মিষ্টি আলু			
১০. সরিষা			

১১ দেশী জাতের বোরো			
১২. উফশী বোরো			
১৩. আউশ			
১৪. পাট			
১৫. বোনা আমন			
১৬. রোপা আমন			
১৭. উফশী আমন			
১৮. ইক্ষু			
১৯. ধনচে			
২০. কাশ বন			
২১. অন্যান্য (উল্লেখ করুন)			

(যে সব ফসল এক জমিতে চাষ করা হয় সেসব ক্ষেত্রে জমির পরিমাণ একত্রে নোট করে তা খ.১৩ এর শতকরা কত ভাগ তা হিসেব করে লিখুন)।

ঙ.৪ মৌজা/গ্রামে গৃহপালিত পশু এবং হাঁস-মুরগীর – আনুমানিক সংখ্যা

প্রকরণ	শুষ্ক মওসুমে সংখ্যা	বর্ষাকালে সংখ্যা
১. গরু		
২. মহিষ		
৩. ছাগল/ভেড়া		
৪. হাঁস/মুরগী		
৫. অন্যান্য (উল্লেখ করুন)		

ঙ.৫ নিম্নলিখিত প্রকৃতির কোন গাছ কি এই মৌজা/গ্রামে আছে?

কলা	হ্যাঁ / না
বাবলা	হ্যাঁ / না
বাঁশ	হ্যাঁ / না
বড়ই	হ্যাঁ / না
আম	হ্যাঁ / না
কাঁঠাল	হ্যাঁ / না

চ. দুর্যোগ ও তার ক্ষতির পরিমাণ

চ.১ গত ৬ (ছয়) বৎসরে মৌজা/গ্রামে বন্যায় কিরূপ ক্ষতি হয়েছে?

বৎসর	শতকরা কত ভাগ চাষ যোগ্য জমি প্লাবিত হয়েছে (%) +	কতদিন বন্যা ছিল	শতকরা কতভাগ বাড়ী প্লাবিত হয়নি	মেঝের উপরে এবং চালের নীচে পানি ছিল শতকরা কত ভাগ ঘরে	চালের উপরে পানি উঠে- ছিল শতকরা কত ভাগ ঘরে	বিনষ্ট হয়েছে শতকরা কতভাগ ঘর	জীবনহানির সংখ্যা
১৯৯২							
১৯৯১							
১৯৯০							
১৯৮৯							
১৯৮৮							
১৯৮৭							

+ *[বিগত বছরে (উচ্চ বা বর্ষায়) শতকরা যে পরিমাণ আবাদযোগ্য জমি চাষ করা যেতো, কিন্তু সর্বোচ্চ বন্যায় তলিয়ে ছিলো। কতদিন তলিয়ে ছিলো তা সর্বোচ্চ বন্যার সময় থেকে বিবেচনা করবেন।]*

চ.২ গত ছয় বৎসরে ভাঙনের ফলে মৌজা/গ্রামের কিরূপ ক্ষতি হয়েছে?

বৎসর	কত একর জমি ভেঙ্গেছে (একর)	কয়টি বাড়ীর ভিটা ভেঙ্গেছে	কতগুলি জীবনহানি হয়েছে
১৯৯২			
১৯৯১			
১৯৯০			
১৯৮৯			
১৯৮৮			
১৯৮৭			

চ.৩ গত পাঁচ বৎসরে নিম্নলিখিত দুর্যোগসমূহ কতবার (যদি হয়ে থাকে) হয়েছে? তন্মধ্যে সবচাইতে গুরুত্বপূর্ণ ক্ষয়ক্ষতি কি? ঐ দুর্যোগে কোন জীবনহানি হয়েছে কি? (কত?)

দুর্যোগ	কতবার ঘটেছে সংখ্যা	প্রধান ক্ষতি (কোড)	জীবনহানির সংখ্যা (জীবনহানি হয়ে থাকলে)
১. বড় রকমের ঝড় (ঘূর্ণিঝড়, যেমন: টর্নেডো)			
২. শিলাবৃষ্টি			
৩. খরা			
৪. ভূমিতে বালির স্তর পড়া			
৫. দুর্ভিক্ষ			
৬. রোগ/মহামারী			
৭. অন্যান্য (উল্লেখ করুন)			

ক্ষতি : ১. ফসল, ২. ঘরবাড়ি, ৩. গরু–ছাগল, ৪. অবকাঠামো (রাস্তা/দালানকোঠা), ৫. হাঁস–মুরগী, ৬. মানুষের জীবনহানি/মৃত্যু, ৭. অন্যান্য (নির্দিষ্ট করে লিখুন)

ছ. ভূমি ব্যবস্থা ও স্বত্ব

ছ.১ চর জাগার পর এই মৌজায় ভূমি বন্টন নিয়ে কোন গোলমাল হয়েছিলো কি? (যেমন গ্রাম্য সালিশীর প্রয়োজন পড়েছে অথবা থানায়/কোর্টে মামলা দায়ের করতে হয়েছে।)

নিম্নলিখিত কোডসমূহের মধ্যে যেটি সঠিক সেটি কোড ধরে লিখুন :

কোড : ১. কখনও না, ২. এক বৎসরের মধ্যে গড়ে একটি/এর ও কম, ৩. এক বৎসরে কয়েকটি, ৪. অনেক

১. যদি সংঘাত হয়ে থাকে তবে এই মৌজার বাহিরে থাকে এমন কোন দল/লোক কি এই সংঘাতে জড়িত ছিল? হাঁ / না

২. জমি সংক্রান্ত সমস্যা নিয়ে কোন সংঘাত হয়েছিলো কি? হাঁ / না

৩. যদি 'হাঁ' হয়, তবে সংঘাতে কি কোন মৃত্যু ঘটেছিল? হাঁ / না

১৫৮

এ প্রশ্নপত্রে উল্লেখ নেই এমন বিশেষ কোন পর্যবেক্ষণ সহ প্রশ্নমালাভুক্ত এলাকার প্রাসঙ্গিক মন্তব্য (প্রয়োজনে অতিরিক্ত সিট ব্যবহার করুন)!

তত্ত্বাবধায়কের স্বাক্ষর ও তারিখ

তথ্যসংগ্রহকারীর পূর্ণনাম স্বাক্ষর ও তারিখ

কোড এবং সাক্ষাৎকার নির্দেশনা ঃ

মৌজা বা গ্রাম ঃ

মৌজাটি যদি চরজাতীয় ভূমি হয় এবং বাস্তবিকই দুই অংশে বিভক্ত থাকে যার প্রতি অংশে এক বা একাধিক গ্রাম রয়েছে সেক্ষেত্রে অবশ্যই মৌজাটির প্রতি অংশের জন্যে একটি করে প্রশ্নপত্র পূরণ করতে হবে। উদাহরণস্বরূপ মৌজাতে একটি গ্রামবিশিষ্ট দ্বীপচর এবং দুইটি গ্রাম বিশিষ্ট নদী তীর সংলগ্ন চর থাকলে সেক্ষেত্রে দ্বীপচরের জন্য একটি এবং নদী তীর সংলগ্ন চরের জন্যে একটি প্রশ্নপত্র (তালিকা প্রণয়ন) পূরণ করতে হবে। এছাড়াও একটি সমগ্র মৌজার প্রতিনিধিত্ব মূলক তথ্য যদি উত্তরদাতা প্রদান করতে অক্ষম হন সে ক্ষেত্রেও একটি মৌজার জন্যে একাধিক প্রশ্নপত্র পূরণ করা যাবে, উদাহরণস্বরূপ অনেক গ্রামসম্বলিত একটি বড় মৌজা। এরূপ ক্ষেত্রে প্রশ্নপত্রের মৌজার জায়গায় গ্রাম বা গ্রামসমূহের নাম লিখতে হবে এবং মানচিত্রে এর সীমানা নির্দেশ করতে হবে।

মূল ইমেজে মৌজা/গ্রাম সনাক্ত করুন, মৌজাটি যদি একাধিক অংশবিশিষ্ট হয় সেক্ষেত্রে প্রতিটি অংশের সীমানা চিহ্নিত করুন এবং প্রতিটির জন্যে আলাদা আলাদা প্রশ্নপত্র ((তালিকা পূরণ করুন। ইমেজে মৌজার অবস্থান যেভাবে দেয়া আছে উত্তরদাতাদের মতে যদি তার অবস্থান ভিন্ন হয় এবং সীমানা সম্পূর্ণ ভিন্ন হয় তবে কার্যক্ষেত্রে প্রাপ্ত সীমানা এবং ইমেজের বিচ্যুতি স্থলগুলো চিহ্নিত করুন এবং মৌজাটি যদি কয়েক অংশে বিভক্ত হয় তবে গ্রামসমূহের নাম লিখুন।

কোডসমূহ ঃ

যেসব ক্ষেত্রে তথ্য পাওয়া যাবে না সেসব ক্ষেত্রে কোড '–৯' লিখুন। উদাহরণস্বরূপ যেসব ক্ষেত্রে কোন উত্তরদাতা কোন প্রশ্নের উত্তর দিতে অক্ষম হবেন বা যেসব ক্ষেত্রে কোন প্রশ্ন জিজ্ঞেস করা হয়নি।

প্রযোজ্য নয় এরূপ ক্ষেত্রে কোড '–৮' লিখুন। উদাহরণস্বরূপ যেখানে জনবসতি নেই সেখানে পেশা প্রশ্ন প্রযোজ্য নয়।

নাই এর ক্ষেত্রে কোড '০' লিখুন। উদাহরণস্বরূপ এলাকায় যদি পাট না জন্মে তবে এক্ষেত্রে '০' লিখুন।

জরীপ চলাকালীন সময়ে যদি মৌজাটি জনবসতিপূর্ণ না হয় সেক্ষেত্রে শুধুমাত্র সেকশন ক, খ, গ, ঙ.২, ঙ.৩, ঙ.৪ এবং ঙ.৫ পূরণ করতে হবে। ১৯৮৬ সাল হতে জরীপ চলাকালীন সময়ের মধ্যবর্তী কোন সময়ে যদি জনবসতি থেকে থাকে তবে সেকশন 'চ'ও পূরণ করতে হবে।

হ্যাঁ/না প্রশ্নসমূহের ক্ষেত্রে কোড হ্যাঁ = ১, না = ২ হবে।

* ড্যাস '–' চিহ্ন গ্রহণযোগ্য নয়।

* শূন্য সংখ্যার জন্য '০' ব্যবহার করুন (উদাহরণস্বরূপ ০ একর, ০% ইত্যাদি। অথবা –৮ প্রযোজ্য নয় এমন ক্ষেত্রে ব্যবহার করুন।

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APPENDIX B

SUMMARY DATA TABLES BY RIVER REACH AND CHAR TYPE

Note: The areas covered by each river reach and char type are shown in Figure 3.1.

Table B.1 Gross Study Area by Reach and Char Land Type (Hectares)

River Reach	Unprotd Mainland West	Attached West	Island Char	Submerged	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	3221	9227	1467	2480	374	2705	9601	5926	19473
Middle Padma	11258	4406	20004	1855	0	13821	4406	25079	51344
Lower Padma	7212	5958	15685	1191	558	7361	6516	14573	37965
Total	21691	19590	37156	5527	932	23887	20523	45578	108783

Source: FAP 19 Satellite Image Estimates Apportioned by Predominant Char Land Type.

Table B.2 Water Area by Reach and Char Land Type From Imagery (Hectares)

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	196	1256	2538	38	675	1294	872	4703
Middle Padma	1485	1252	9875	-	2442	1252	3928	15055
Lower Padma	546	1544	7528	67	1606	1611	2152	11292
Total	2227	4052	19941	105	4724	4157	6951	31050

Source: FAP 19 Satellite Image Estimates Apportioned by Predominant Char Land Type.

Table B.3 Sand Area by Reach and Char Land Type From Imagery (Hectares)

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	119	1180	1226	219	6	1400	125	2751
Middle Padma	961	472	5863	-	310	472	1271	7605
Lower Padma	137	631	2399	68	160	699	296	3394
Total	1217	2284	9488	287	475	2571	1692	13751

Source: FAP 19 Satellite Image Estimates Apportioned by Predominant Char Land Type.

Table B.4 Total Cultivated/Vegetated Area by Reach and Char Land Type From Imagery (Hectares)

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	2906	6791	183	117	2023	6907	4929	12020
Middle Padma	8812	2682	6120	-	11069	2682	19881	28683
Lower Padma	6530	3782	6949	423	5595	4205	12125	23279
Total	18247	13254	13252	540	18688	13794	36935	63982

Source: FAP 19 Satellite Image Estimates Apportioned by Predominant Char Land Type.

Table B.5 1993 Cultivated Land Areas Calculated From Questionaire Returns and Digitized Mauza Area (Hectares)

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	2434	5967	72	197	2099	6164	4533	10769
Middle Padma	9114	2797	11297	0	10606	2797	19720	33814
Lower Padma	6014	4103	9649	409	4720	4512	10733	24894
Total	17561	12867	21018	606	17425	13473	34986	69477

Source: FAP 16 Field Survey Mauza Estimates Apportioned by Predominant Charland Type 1992.

Table B.6 Population Numbers 1981

River Reach	Unprotd Mainland West	Attached West	Island Char	Submerged	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	21834	40611	2607	788	1210	21978	41821	43812	89028
Middle Padma	71573	14891	28327	7532	-	128474	14891	200047	250797
Lower Padma	57380	35385	55193	3709	1515	91161	36900	148541	244343
Total	150787	90887	86127	12029	2725	241613	93612	392400	584168

Source: FAP 16 Field Survey Mauza Estimates Apportioned by Predominant Charland Type

Table B.7 Population Numbers 1993

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	36881	40549	-	738	35158	41287	72039	113326
Middle Padma	84740	11861	22198	-	177733	11861	262473	296532
Lower Padma	60200	35689	33432	3669	75807	39358	136007	208797
Total	181821	88099	55630	4407	288698	92506	470519	618655

Source: FAP 16 Field Survey Mauza Estimates Apportioned by Predominant Charland Type

Table B.8 Aggregate Population Densities 1993 per Square Km of Total Area

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	1145	439	-	197	1300	430	1216	667
Central Padma	753	269	111	-	1286	269	1047	599
Lower Padma	835	599	213	615	1030	600	933	567
Total	838	450	150	454	1209	450	1032	599

Source: FAP 16 Field Survey and Landsat Imagery.

Table B.9 Change in Population Density 1981 to 1993 per Km Square of Total Area

	Unprotd Mainland West	Attached West	Island Char	Submerged	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	467	-1	-178	-32	-126	487	-6	476	125
Central Padma	117	-69	-31	-406		356	-69	249	89
Lower Padma	39	5	-139	-311	361	-209	37	-86	-94
Total	143	-14	-82	-218	173	197	-5	171	32

Source: FAP 16 Field Survey and BBS Small Atlases Apportioned by Predominant Charland Type.

Table B.10 Human Population Densities 1993 per Km square of Cultivated/Vegetated Land Area

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	1269	597	-	631	1738	598	1462	943
Central Padma	962	442	363	-	1606	442	1320	1034
Lower Padma	922	944	481	867	1355	936	1122	897
Total	996	665	420	816	1545	671	1274	967

Source: FAP 16 Field Survey Mauza Estimates Apportioned by Prediminant Charland Type.

Table B.11 Population Densities 1993 per Km Square of Dry Season Unflooded Land Area

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	1219	509	-	220	1733	497	1425	767
Central Padma	867	376	185	-	1562	376	1241	817
Lower Padma	903	809	358	747	1317	803	1095	783
Total	934	567	245	533	1507	565	1218	796

Source: FAP 16 Field Survey Mauza Estimates Apportioned By Predominant Charland Type.

Table B.12 Households Numbers 1993

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	6761	8225	-	128	6187	8353	12948	21301
Middle Padma	15755	2333	3885	-	30851	2333	46606	52824
Lower Padma	12252	7495	6805	694	13882	8189	26134	41128
Total	34768	18053	10690	822	50920	18875	85688	115253

Source: FAP 16 Field Survey Mauza Estimates Apportioned by Predominant Charland Type

Table B.13 Mean Household Size

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	5.5	4.9		5.8	5.7	4.9	5.6	5.3
Central Padma	5.4	5.1	5.7		5.8	5.1	5.6	5.6
Lower Padma	4.9	4.8	4.9	5.3	5.5	4.8	5.2	5.1
Total	5.2	4.9	5.2	5.4	5.7	4.9	5.5	5.4

Source: FAP 16 Field Survey Mauza Estimates Apportioned by Predominant Charland Type 1993

Table B.14 Number of Permanent Out-Migrant Households 1992

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	0	0	0	0	72	0	72	72
Middle Padma	182	0	41	0	139	0	321	362
Lower Padma	0	165	52	1	223	166	223	441
Total	182	165	93	1	434	166	616	875

Source: FAP 16 Field Survey Mauza Estimates Apportioned by Predominant Charland Type

Table B.15 Permanent Out-Migrants Housholds as Percentage of Char/Reach Type 1993 Households

River Reach	Unprotd Mainland West	Attached west	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	0.0	0.0	-	0.0	1.2	0.0	0.6	0.3
Middle Padma	1.2	0.0	1.0	-	0.5	0.0	0.7	0.7
Lower Padma	0.0	2.2	0.8	0.1	1.6	2.0	0.9	1.1
Total	0.6	0.9	0.9	0.1	0.9	0.9	0.8	0.8

Source: FAP 16 Field Survey Mauza Estimatesd Apportioned by Predominant Charland Type.

Table B.16 Number of Permanent In-Migrant Households 1992

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	165	2	0	32	111	34	276	310
Middle Padma	446	0	303	0	1325	0	1771	2074
Lower Padma	72	182	740	35	99	217	171	1128
Total	683	184	1043	67	1535	251	2218	3512

Source: FAP 16 Field Survey Mauza Estimates Apportioned by Predominant Charland Type.
Note : 3 Mauzas with Missing Data.

Table B.17 Permanent In-Migrant Households in 1992 as Percentage of Char/Reach Type 1993 Households

River Reach	Unprotd Mainland West	Attached west	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	2.4	0.0	-	25.0	1.8	0.4	2.1	1.5
Middle Padma	2.9	0.0	7.8	-	4.6	0.0	4.0	4.1
Lower Padma	0.7	2.4	10.9	5.0	0.7	2.6	0.7	2.9
Total	2.1	1.0	9.8	8.2	3.1	1.3	2.7	3.2

Source: FAP 16 Field Survey Mauza Esitmates Apportioned by Predominant Charland Type 1993.

Table B.18 Number of Seasonal Out-Migrants in 1992

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	6	44	0	0	189	44	195	239
Middle Padma	45	25	206	0	2350	25	2395	2626
Lower Padma	7	100	110	28	4014	128	4021	4259
Total	58	169	316	28	6553	197	6611	7124

Source: FAP 16 Field Survey Mauza Estimates Apportioned by Predominant Charland Type

Table B.19 Seasonal Out-migrants in 1992 as Percentage of Char/Reach Population

River Reach	Unprotd Mainland West	Attached west	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	0.02	0.11	-	0.00	0.54	0.11	0.27	0.21
Middle Padma	0.05	0.21	0.93	-	1.41	0.21	0.95	0.92
Lower Padma	0.01	0.28	0.33	0.76	5.30	0.33	3.19	2.14
Total	0.03	0.19	0.57	0.64	2.36	0.21	1.47	1.19

Source: FAP 16 Field Survey Mauza Estimates Apportioned by Predominant Charland Type 1993.

Table B.20 Number of Seasonal In-Migrant 1993

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	0	0	0	0	10	0	10	10
Middle Padma	20	0	117	0	1453	0	1473	1590
Lower Padma	40	10	78	6	500	16	540	634
Total	60	10	195	6	1963	16	2023	2234

Source: FAP 16 Field Survey Mauza Estimates Apportioned by Predominant Charland Type

Table B.21 Seasonal In-Migrant in 1992 as Percentage of Char/Reach Type 1993 Population

River Reach	Unprotd Mainland West	Attached west	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	0.00	0.00	-	0.00	0.03	0.00	0.01	0.01
Middle Padma	0.02	0.00	0.53	-	0.87	0.00	0.59	0.56
Lower Padma	0.08	0.03	0.23	0.16	0.66	0.04	0.43	0.32
Total	0.04	0.01	0.35	0.14	0.71	0.02	0.45	0.37

Source: FAP 16 Field Survey Mauza Estimates Apportioned by Predominant Charland Type 1993.

Table B.22 Number of Mauzas with Primary School

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	9	14	0	1	8	15	17	32
Middle Padma	21	3	15	0	34	3	55	73
Lower Padma	15	6	10	2	21	8	36	54
Total	45	23	25	3	63	26	108	159

Source: FAP 16 Field Survey

Table B.23 Number of Mauzas with High School

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	3	2	0	0	3	2	6	8
Middle Padma	15	1	6	0	5	1	20	27
Lower Padma	7	2	3	1	10	3	17	23
Total	25	5	9	1	18	6	43	58

Source: FAP 16 Field Survey

Table B.24 Number of Mauzas with Health Care Facilities

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	3	2	0	0	3	2	6	8
Middle Padma	5	1	0	0	15	1	20	21
Lower Padma	5	2	1	0	13	2	18	21
Total	13	5	1	0	31	5	44	50

Source: FAP 16 Field Survey

Table B.25 Number of Households with Agriculture as Their Main Occupation in 1993

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	4174	3180	0	42	2402	3223	6576	9799
Middle Padma	6920	623	1573	0	11697	623	18617	20814
Lower Padma	5781	3527	3169	278	3987	3805	9768	16742
Total	16876	7331	4743	320	18086	7651	34962	47355

Source: FAP 16 Field Survey Mauza Estimates Apportioned by Predominant Charland Type.

Table B.26 Percentage of Households with Agriculture as Their Main Occupation in 1993

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	61.7	38.7	0.0	32.8	38.8	38.6	50.8	46.0
Middle Padma	45.4	26.7	40.5	0.0	40.5	26.7	42.2	41.4
Lower Padma	57.9	47.1	46.6	40.1	28.7	46.5	40.9	43.1
Total	52.8	40.6	44.4	38.9	37.0	40.5	43.2	42.9

Source: FAP Field Survey Mauza Estimates Apportioned by Predominant Chanland Type 1993.

Table B.27 Number of Households with Fishing as Their Main Occupation in 1993

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	168	1213	0	57	246	1270	414	1684
Middle Padma	1275	446	895	0	1509	446	2784	4125
Lower Padma	221	335	1207	4	558	339	779	2325
Total	1664	1994	2102	61	2313	2055	3977	8134

Source: FAP 16 Field Survey Mauza Estimates Apportioned by Predominant Charland Type

Table B.28 Percentage of Households with Fishing as Their Main Occupation in 1993

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Tota Attached	Sub Total Unprotd Mainland	Total
Upper Padma	2.5	14.7	0.0	44.5	4.0	15.2	3.2	7.9
Middle Padma	8.4	19.1	23.0	0.0	5.2	19.1	6.3	8.2
Lower Padma	2.2	4.5	17.7	0.6	4.0	4.1	3.3	6.0
Total	5.2	11.0	19.7	7.4	4.7	10.9	4.9	7.4

Source: FAP 16 Field Survey Mauza Estimates Apportioned by Predominant Charland Type 1993

Table B.29 Percentage of Households with Fishing as Second Occupation in 1993

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	3.0	23.8	0.0	47.7	6.2	24.1	4.5	12.2
Middle Padma	8.8	28.4	25.1	0.0	9.5	28.4	9.3	11.4
Lower Padma	3.6	4.1	16.5	6.3	11.6	4.3	8.3	8.9
Total	6.0	16.2	19.6	12.9	9.7	16.1	8.2	10.7

Source: FAP 16 Field Survey Mauza Estimates Apportioned By Predominant Charland Type 1993.

Table B.30 Main Occupation (Percentages of Households) by Char Type

Occupation	Island Char	Attached Char	Unp.mainland	Total
Cultivating	44.4	40.4	43.2	42.9
Fishing	19.7	10.9	4.9	7.4
Agric. Labor	15.9	27.1	18.7	19.9
Non-Agr. Labor	6.2	8.2	8.1	8.0
Transport	2.1	2.2	2.1	2.1
Petty Business	7.8	7.9	11.2	10.3
Large Business	.2	.3	1.3	1.0
Service	.9	1.1	2.8	2.3
Paid HH Work	1.5	1.4	1.7	1.6
Remit.From Abroad	1.3	.3	3.9	3.0
Others	.0	.2	1.4	1.1
No Livelihood	.2	.1	.5	.4
Total	100.0	100.0	100.0	100.0

Source: FAP 16 Field Survey Mauza Estimates Apportioned by Predominant Charland Type 1993.

Table B.31 Cropping Intensities (percentage of cultivable land cultivated in a year)

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	173	194	129	131	178	192	175	185
Middle Padma	211	189	170	-	174	189	190	186
Lower Padma	184	189	157	185	139	188	163	166
Total	195	191	162	173	164	190	179	178

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type
Note: 2 Mauzas with Missing Data.

Table B.32 Average Percentage of Sandy Land Reported

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	29	46	91	74	25	48	27	45
Middle Padma	17	25	58	-	11	25	13	31
Lower Padma	15	35	48	9	14	32	14	28
Total	21	42	60	58	14	44	17	35

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type
Note: 1 Mauza with Missing Data, data for all mauzas reporting soil type.

Table B.33 Cropping Pattern (percentage of cultivable land under main crops)

Crop	Island Char	Attached Char	Unprotected Mainland	Upper Reach	Middle Reach	Lower Reach	Total
Kaon	0.7	1.2	0.9	0.9	1.0	0.8	0.9
Groundnut	20.9	15.7	4.2	9.9	8.8	11.7	10.1
Dhal	11.8	9.5	10.3	8.0	13.9	7.3	10.4
Onion	7.8	11.5	9.9	9.2	10.9	8.6	9.8
Til	1.8	0.3	2.1	1.1	1.6	2.0	1.7
Chilli	2.3	6.8	4.9	5.1	4.3	5.2	4.8
Wheat	4.0	18.2	14.2	19.4	15.0	7.0	12.9
Potato	0.0	0.5	2.0	1.5	1.0	1.5	1.3
Sweet Potato	1.0	2.6	1.1	2.4	1.9	0.3	1.4
Mustard	3.8	2.0	5.9	1.2	4.8	6.2	4.7
L Boro	11.2	12.1	10.6	13.2	7.9	13.8	11.0
HYV Boro	2.4	2.1	13.8	6.1	7.8	11.7	8.9
Aus	48.3	51.9	48.3	42.2	49.6	51.6	48.9
Jute	2.4	7.8	5.5	10.2	5.2	3.1	5.4
B Aman	28.2	39.2	39.7	42.9	42.3	27.7	37.1
TL Aman	0.0	0.3	0.0	0.3	0.0	0.0	0.1
HYV Aman	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sugarcane	0.3	0.4	0.8	0.3	0.6	0.8	0.6
Dhaincha	1.4	1.8	3.6	1.3	3.1	3.0	2.7
Others	0.0	0.4	0.2	1.2	0.0	0.0	0.2
Total	148.3	184.3	178.0	176.4	179.7	162.3	172.9

Source: FAP 16 Inventory Survey

Table B.34 Mean Yields (tn/ha) of Main Crops

Crop	Island Char	Attached Char	Unprotected mainland	Total
Kaon	1.01	1.16	1.39	1.24
Groundnut	2.60	1.90	2.50	2.35
Dhal	1.27	1.26	1.26	1.26
Onion	8.39	8.67	9.26	8.92
Til	1.21	0.99	1.09	1.10
Chilli	2.79	1.84	1.98	2.09
Wheat	1.59	1.87	2.12	2.01
Potato	-	13.32	19.76	18.78
Sweet Potato	23.30	18.05	20.55	20.49
Mustard	1.19	1.15	1.18	1.18
L Boro	2.78	2.11	2.56	2.53
HYV Boro	5.56	4.69	5.14	5.13
Aus	1.88	1.80	1.87	1.86
Jute	1.70	1.62	1.74	1.70
B Aman	2.26	1.94	2.35	2.25
TL Aman	-	2.03	2.58	2.31

Source: FAP 16 Inventory Survey

Table B.35 Number of Mauzas Which have Faced Problems of Land Disputes/Allocation

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	14	29	2	1	19	30	33	65
Middle Padma	17	4	28	0	48	4	65	97
Lower Padma	7	3	16	2	4	5	11	32
Total	38	36	46	3	71	39	109	194

Source: FAP 16 Field Survey

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Table B.36 Total Number of Large Livestock in 1993 Dry Season

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	4967	5172	0	386	5065	5558	10032	15590
Middle Padma	8600	1256	3467	0	18811	1256	27411	32134
Lower Padma	3922	4717	3740	520	6925	5237	10847	19824
Total	17489	11145	7207	906	30801	12051	48290	67548

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type

Table B.37 Total Number of Large Livestock in 1992 Monsoon Season

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	3981	4312	0	252	4278	4564	8259	12823
Middle Padma	6269	896	2866	0	16399	896	22668	26430
Lower Padma	3357	3852	3075	380	6455	4232	9812	17119
Total	13607	9060	5941	632	27132	9692	40739	56372

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type

Table B.38 Large Livestock per Cultivated km Square in 1993

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	172	77	0	210	250	80	204	130
Middle Padma	98	47	57	0	171	47	138	112
Lower Padma	60	125	54	123	124	125	90	85
Total	96	85	54	149	165	87	131	106

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type

Table B.39 Large Livestock per km Square Dry Season Land in 1993

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	166	65	0	95	250	67	200	106
Middle Padma	88	40	29	0	166	40	130	89
Lower Padma	59	107	40	106	121	107	87	74
Total	90	72	32	101	161	74	125	87

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type

Table B.40 Number of Large Livestock per 100 Households in 1993

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	73	64	0	162	82	67	77	73
Middle Padma	56	54	89	0	65	54	62	64
Lower Padma	39	63	55	75	50	64	45	51
Total	55	62	67	97	63	64	60	61

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type

Table B.41 Total Number of Small Livestock (Goat/Sheep) in 1993 Dry Season

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	6199	7772	0	601	4185	8373	10384	18757
Middle Padma	12152	1385	3578	0	16658	1385	28810	33773
Lower Padma	2293	3863	3953	175	4391	4038	6684	14675
Total	20644	13020	7531	776	25234	13796	45878	67205

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type

Table B.42 Density of Small Livestock in 1993 to Dry Season Land Area

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	207	98	0	149	206	101	207	127
Middle Padma	124	44	30	0	147	44	137	93
Lower Padma	34	88	42	36	76	82	54	55
Total	106	84	33	87	132	84	119	87

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type

Table B.43 Ratio of Small Livestock to 100 Human Households in 1993

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	92	96	0	253	68	100	80	88
Middle Padma	80	59	92	0	58	59	65	67
Lower Padma	23	52	58	25	32	49	28	38
Total	65	73	70	83	52	73	57	61

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type

Table B.44 Total Number of Poultry in 1993

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	16057	26976	0	1690	18350	28666	34407	63073
Middle Padma	68579	4480	15966	0	76808	4480	145387	165833
Lower Padma	37265	20985	15200	925	27040	21910	64305	101415
Total	121901	52441	31166	2615	122198	55056	244099	330321

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type

Table B.45 Ratio of Poultry Per 100 Households in 1993

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	238	332	0	710	297	343	266	296
Middle Padma	450	192	411	0	266	192	330	330
Lower Padma	373	280	223	133	195	268	269	261
Total	381	292	292	281	250	292	302	299

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type

Table B.46 Number of Non-Mechanized Boats in 1993

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	273	1628	0	64	384	1692	657	2349
Middle Padma	2145	528	1057	0	3209	528	5354	6939
Lower Padma	410	585	1133	23	443	608	853	2594
Total	2828	2741	2190	87	4036	2828	6864	11882

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type

Table B.47 Households Per Non-Mechanized Boat in 1993

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	25	5	0	4	16	5	20	9
Middle Padma	7	4	4	0	9	4	8	7
Lower Padma	24	13	6	30	31	13	28	15
Total	11	7	5	11	12	7	12	9

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type

Table B.48 Number of Mechanized Boats in 1993

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	9	128	0	8	20	136	29	165
Middle Padma	94	37	104	0	264	37	358	499
Lower Padma	91	213	234	0	71	213	162	609
Total	194	378	338	8	355	386	549	1273

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type

Table B.49 Households Per Mechanized Boats in 1993

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	751	63	0	30	309	61	446	129
Middle Padma	162	63	37	0	109	63	123	101
Lower Padma	110	35	29	0	196	38	147	64
Total	165	47	32	117	138	49	147	87

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type

Table B.50 Number of Human Deaths (Indirect and Direct) from the 1988 Flood

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	32	59	0	5	8	64	40	104
Middle Padma	20	1	30	0	48	1	68	99
Lower Padma	0	0	0	0	18	0	18	18
Total	52	60	30	5	74	65	126	221

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type
Note: 1 Mauza with Missing Data.

Table B.51 1988 Floods Deaths per 100,000 People (1993 Population)

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	87	148	0	368	23	155	56	92
Middle Padma	24	8	135	0	29	8	27	35
Lower Padma	0	0	0	0	24	0	14	9
Total	30	69	54	99	27	70	28	37

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type
Note: 1 Mauza with Missing Data.

Table B.52 Number of Human Deaths from Epidemic Disease 1988-92

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	202	216	0	0	94	216	296	512
Middle Padma	180	63	138	0	263	63	443	644
Lower Padma	84	19	11	0	34	19	118	148
Total	466	298	149	0	391	298	857	1304

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type

Table B.53 Death From Epidemic Disease in 1988-92 per 100,000 People (1993 Population)

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	548	533	0	0	267	523	411	452
Middle Padma	212	531	622	0	148	531	169	217
Lower Padma	140	53	33	0	45	48	87	71
Total	256	338	268	0	135	322	182	211

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type

Table B.54 Percentage of Area Flooded at Peak Flood Time 1987

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	73	63	100	100	93	64	81	71
Middle Padma	69	84	91	-	85	84	78	81
Lower Padma	63	61	56	-	58	54	61	58
Total	68	67	73	24	78	65	73	71

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type
Note: 1 Mauza with Missing Data.

Table B.55 Mean Days Duration of Flooding 1987

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	30	29	60	32	21	29	26	28
Middle Padma	44	27	28	-	33	27	36	33
Lower Padma	29	44	24	-	22	38	25	27
Total	34	32	28	21	29	31	31	30

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type
Note: 4 Mauzas with Missing Data.

Table B.56 Percentage of Area Flooded at Peak Flood Time 1988

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	100	100	100	100	100	100	100	100
Middle Padma	100	100	100	-	100	100	100	100
Lower Padma	100	100	100	100	100	100	100	100
Total	100	100	100	100	100	100	100	100

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type

Table B.57 Mean Days Duration of Flooding 1988

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	44	46	70	47	28	46	37	42
Middle Padma	55	38	37	-	32	38	37	37
Lower Padma	48	48	47	25	40	45	43	44
Total	49	46	41	39	33	46	39	40

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type
Note: 2 Mauzas with Missing Data.

Table B.58 Percentage of Area Flooded at Peak Flood Time 1991

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	44	37	100	68	77	37	58	46
Middle Padma	52	56	88	-	82	56	69	71
Lower Padma	56	64	60	15	47	58	52	55
Total	52	48	72	29	71	47	62	61

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type
Note: 7 Mauzas with Missing Data.

Table B.59 Mean Days Duration of Flooding 1991

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	20	18	25	30	16	19	19	19
Middle Padma	28	12	29	-	35	12	34	32
Lower Padma	28	48	28	5	19	42	23	27
Total	25	24	28	23	29	24	28	27

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type
Note: 24 Mauzas with Missing Data.

Table B.60 Percentage of Area Flooded During 1989-92

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	43	35	100	62	78	36	57	45
Middle Padma	51	58	88	0	81	58	68	71
Lower Padma	54	63	60	8	50	58	53	56
Total	51	48	72	22	72	47	61	60

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type
Note: 7 Mauzas with Missing Data.

Table B.61 Mean Days Duration of Flooding 1989-92

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	19	17	27	28	17	18	18	18
Middle Padma	28	12	30	0	34	12	33	31
Lower Padma	28	52	38	5	21	46	24	32
Total	25	25	33	21	29	24	27	28

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type
Note: 25 Mauzas with Missing Data.

Table B.62 Percentage of Houses which are all Kutcha

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	50.3	61.2	0.0	90.6	15.8	61.6	33.8	44.7
Middle Padma	36.6	69.1	48.5	0.0	24.6	69.1	28.7	32.1
Lower Padma	47.9	33.9	55.5	24.8	20.0	33.1	31.7	36.1
Total HH's	43.0	50.9	52.9	35.2	22.2	50.2	30.4	36.0

Source: FAP 16 Field Survey Mauza Estimates Apportioned by Predominant Charland Type

Table B.63 Number of Households Per Radio By Reach and Char Type

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	14.1	3.9	0.0	5.6	10.1	3.9	11.9	6.6
Middle Padma	4.6	5.3	5.9	0.0	4.6	5.3	4.6	4.7
Lower Padma	19.6	8.8	10.5	14.8	2.7	9.2	4.3	5.5
Total	7.4	5.3	8.2	11.7	4.1	5.5	4.9	5.2

Source: FAP 16 Field Survey Mauza Estimates Apportioned by Predominant Charland Type.

Table B.64 Percentage of Houses Flooded in 1987

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	49	34	-	74	60	38	55	46
Middle Padma	23	64	36	-	26	64	25	29
Lower Padma	0	8	0	-	4	7	2	3
Total	22	30	24	50	27	32	26	27

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type
Note: 5 Mauzas with Missing Data.

Table B.65 Percentage of Houses Destroyed by Flood 1987

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	13	18	-	24	11	18	12	15
Middle Padma	6	26	14	-	7	26	7	9
Lower Padma	0	0	0	-	0	0	0	0
Total	6	14	10	16	6	14	6	8

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type
Note: 5 Mauzas with Missing Data.

Table B.66 Percentage of Houses Flooded in 1988

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	100	99	-	100	100	100	100	100
Middle Padma	100	100	100	-	100	100	100	100
Lower Padma	90	84	100	100	99	86	95	94
Total	96	96	100	100	99	96	98	98

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type
Note: 1 Mauza with Missing Data.

Table B.67 Percentage of Houses Destroyed by Flood 1988

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	46	67	0	41	32	64	39	51
Middle Padma	26	70	48	0	26	70	26	32
Lower Padma	2	2	19	13	13	3	8	9
Total	23	52	40	32	24	50	24	31

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type
Note: 1 Mauza with Missing Data.

Table B.68 Mean Percentage of Houses Flooded 1989-92

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	1	2	-	16	4	4	3	3
Middle Padma	2	3	6	-	4	3	3	4
Lower Padma	0	0	0	2	3	0	2	1
Total	1	2	4	12	4	3	3	3

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type
Note: 2 Mauzas with Missing Data.

Table B.69 Mean Percentage of Houses Destroyed by Flood 1989-92

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	1.4	1.0	-	7.4	0.0	1.8	0.7	1.2
Middle Padma	0.5	3.3	1.5	-	0.7	3.3	0.7	0.9
Lower Padma	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.6	0.9	0.9	5.3	0.5	1.4	0.5	0.7

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type
Note: 2 Mauzas with Missing Data.

Table B.70 Area Eroded in 1987 by Reach and Char Type (Hectares)

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	6	43	0	0	38	43	44	87
Middle Padma	38	64	149	0	33	64	70	283
Lower Padma	0	20	488	0	37	20	37	545
Total	44	127	637	0	108	127	152	915

Source: FAP 16 Field Survey Mauza Estimates Apportioned by Predominant Charland Type

Table B.71 Area Eroded in 1988 by Reach and Char Type (Hectares)

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	19	115	0	0	63	115	82	197
Middle Padma	130	138	308	0	79	138	210	656
Lower Padma	45	304	716	4	78	308	123	1147
Total	195	556	1025	4	220	560	415	2000

Source: FAP 16 Field Survey Mauza Estimates Apportioned by Predominant Charland Type.

Table B.72 Area Eroded From 1989 to 1992 by Reach and Char Type (Hectares)

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	20	151	0	0	72	151	92	243
Middle Padma	707	96	1331	0	578	96	1284	2710
Lower Padma	11	226	308	11	545	237	556	1101
Total	738	472	1639	11	1194	483	1932	4054

Source: FAP 16 Field Survey Mauza Estimates Apportioned by Predominant Charland Type

Table B.73 Homesteads Eroded in 1987 by Reach and Char Type

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	5	19	0	0	51	19	56	75
Middle Padma	7	17	83	0	40	17	47	147
Lower Padma	0	20	171	0	23	20	23	214
Total	12	56	254	0	114	56	126	436

Source: FAP 16 Field Survey Mauza Estimates Apportioned by Predominant Charland Type

Table B.74 Homesteads Eroded in 1988 by Reach and Char Type

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	30	170	0	0	57	170	87	257
Middle Padma	163	55	187	0	109	55	272	514
Lower Padma	50	180	289	4	53	184	103	576
Total	243	405	476	4	219	409	462	1347

Source: FAP 16 Field Survey Mauza Estimates Apportioned by Predominant Charland Type

Table B.75 Homesteads Eroded From 1989 to 1992 by Reach and Char Type

River Reach	Unprotd Mainland West	Attached West	Island Char	Attached East	Unprotd Mainland East	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper Padma	30	54	0	0	39	54	69	123
Middle Padma	372	29	343	0	765	29	1137	1509
Lower Padma	5	201	458	3	636	204	641	1303
Total	407	284	801	3	1440	287	1847	2935

Source: FAP 16 Field Survey Mauza Estimates Apportioned by Predominant Charland Type