BANGLADESH FLOOD ACTION PLAN

Ministry of Water Resources

Flood Plan Coordination Organization (FPCO)

Prepared by

Environmental Study (FAP 16)

Geographic Information System (FAP 19)

ISPAN

IRRIGATION SUPPORT PROJECT FOR ASIA AND THE NEAR EAST

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Ministry of Water Resources
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The Dynamic Physical and Human Environment of Riverine Charlands: GANGES

April 1995

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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 the last part of the work of Phase 2 of ISPAN's resource inventory of riverine chars, the charlands of the Ganges 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.

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GLOSSARY

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

SPARRSO	-	Space Research and Remote Sensing Organization
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EXECUTIVE SUMMARY
GANGES

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. In the dry season the Ganges channels which separate islands from the mainland may dry up in places, even though the char is an island in the monsoon, so the distinction between island and attached chars is not always clear. Most unprotect-

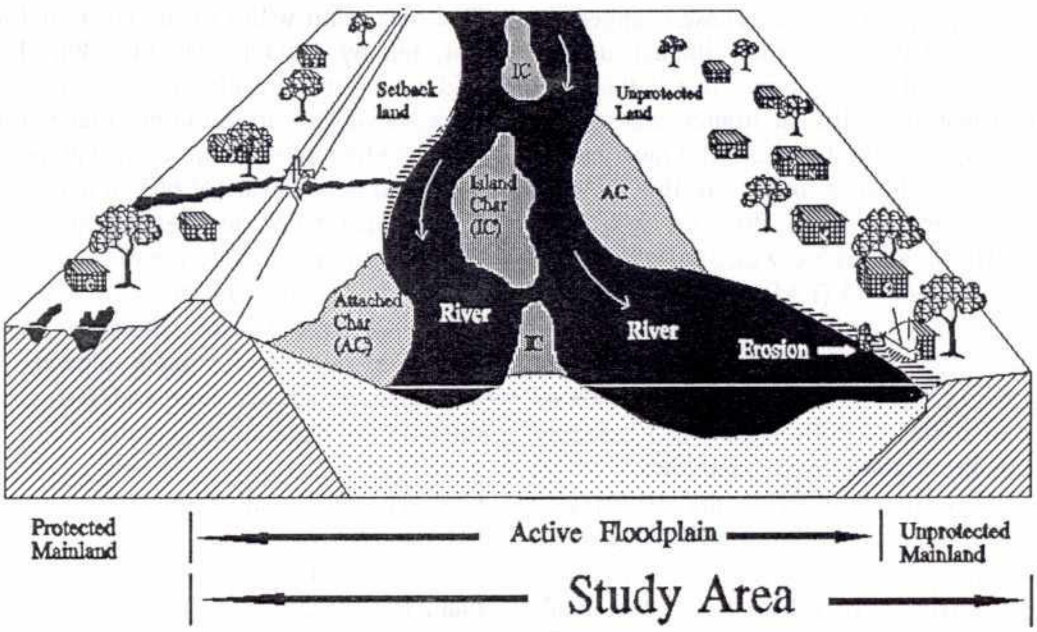

Figure 1: Charland Classification

ed mainland in the Ganges chars is setback land between embankments and the bankline.

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

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

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

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

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

The maximum width of the river in 1984 was 10 km, but by 1993 it was 11.7 km. Erosion and widening rates locally have been much higher: near Nawabganj in the upper reach, for instance, the bankline moved up to 6 km north in nine years, an erosion rate of 665 m per year sustained over almost a decade. Net erosion rates of more than 200 m per year for the nine-year period were found at less than 14 percent of cross-sections. Averaged over reaches, however, erosion and accretion rates were much slower than these extremes, which are comparable to rapid erosion rates on the Padma and Jamuna.

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

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

Table 1 Qualitative Summary of Differences between Char Land Types - Ganges

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

Source: FAP 16 Charland Inventory

Table 2 Summary of Mauza Inventory Data by Char Land Type - Ganges

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

Source: FAP 16/19 inventory and satellite image analysis

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

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

Table 3 Summary of Mauza Inventory Data by Reach - Ganges

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

Source: FAP 16/19 inventory and satellite image analysis

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

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

population to have been 697,000, of which about 54,000 lived in island char mauzas. The attached char population was 141,000, and there were 501,000 people on unprotected mainland, including setback land. Between 1981 and 1993 the total charland population grew by only 6 percent, but in this period there were major shifts in the distribution of people, partly due to bank erosion.

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

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

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

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

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

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

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

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

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

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

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

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

The 1988 flood was estimated to be about a 1-in-60-year event in the lower reach; the return period in the other reaches is uncertain. In that year, 86 percent of houses in the Ganges charlands were flooded and 27 percent were destroyed. Although the proportion flooded increased going downstream, the proportion destroyed was constant. On average, only 3 percent of houses were flooded in each year during the 1989-92 period. Only in 1988 was there a substantial number of flood-related

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deaths: about 231 people were killed, 38 percent of them in the middle reach island chars. Epidemic diseases were reported to have killed more people during the period 1988-92, particularly in the same areas that reported the most flood deaths.

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

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

This is the first study to collect data for the whole of the Ganges 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 interventions may affect the Ganges 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.

Since movements of the Ganges may be more predictable than for the other main rivers, and because some island chars have persisted over several decades, there may be scope to increase the longevity of chars and encourage more productive use of the land and provide better services. Even so, permanent structures in the island chars and active river corridor will be risky unless river training works can be implemented using local materials and prove effective and sustainable.

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

Many char people are also at risk from erosion, which displaced about 60,000 people in the Ganges charlands in the past decade. There is no reason to believe that the next decade will be any different as meanders continue to move and evolve. River training works may be possible where the more predictable meander system can be stabilized, but there will still be risks. The area of island chars has been increasing rapidly, however, and low cost measures to stabilize island chars might create more land, increase its productivity, increase the duration of settlement, and—if coupled with flood proofing—reduce risks.

Chapter 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.[1] (Notes follow each chapter.) 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 final stage of Phase 2 of the FAP 16/19 Charland Study: the Ganges charland inventory. It consists of analysis, maps, and summary data tables dealing with population, land and resource use, and hazards for each mauza. Satellite images and analysis of changes in the Ganges 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 Ganges Study Area

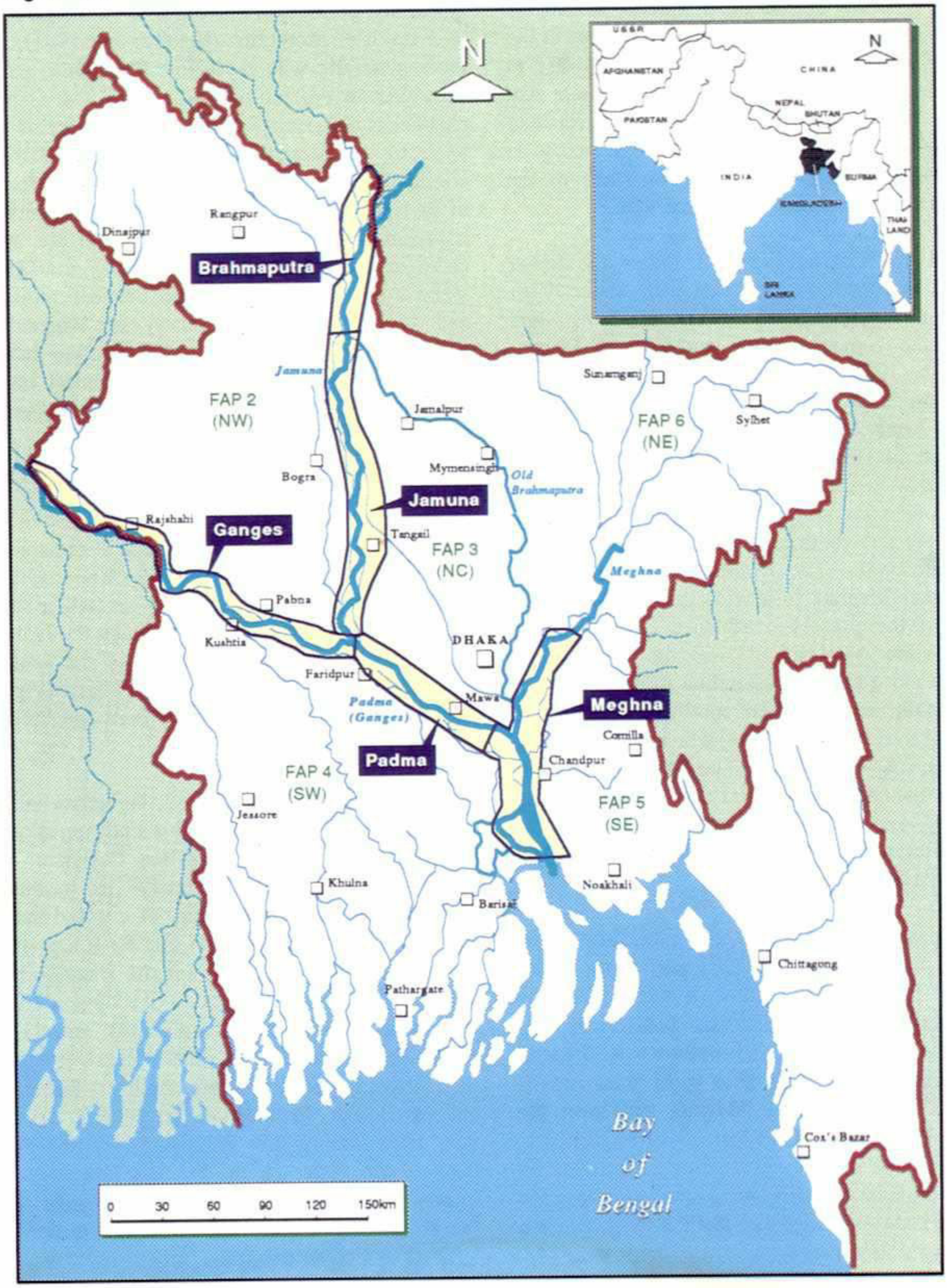
1.2.1 Delineation of Study Area

In Bangladesh, the course of the Ganges (Figure 1.1) has changed less in the past 200 years than the other main rivers of the Ganges-Brahmaputra-Meghna delta. The Ganges forms the international border,[2] or flows near the border for its initial 90 km in Bangladesh. It then continues for another 100 km to the confluence with the Jamuna, after which the combined flow is known as the Padma.

The Ganges catchment covers 1.07 million km^2 (Rogers *et al.*, 1989), 93 percent of which is outside Bangladesh in India and Nepal. The Ganges has been a major contributor to the delta building process which has created the land of Bangladesh. While the size of the catchment outside Bangladesh has changed little in historic times, the course within what is now Bangladesh has gradually changed, as the active part of the Ganges delta has migrated eastward.

Figure 1.1

Charland Study Location



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

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

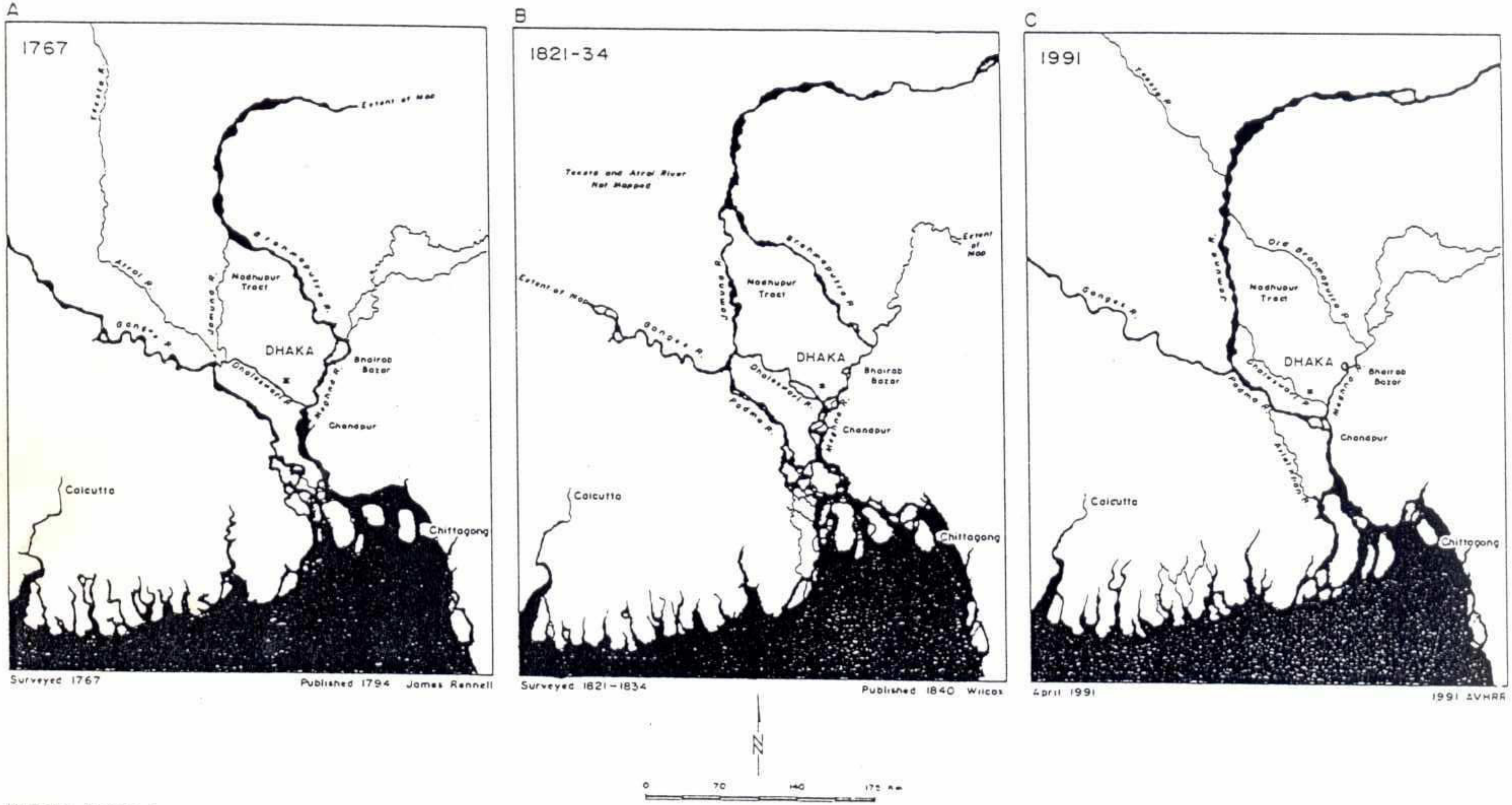
In the past 200 years, then, the main flow of the Brahmaputra moved 60 km west, the Upper Meghna lost much of its flow, a major new river (the Jamuna) was created, a vast river (the Padma) combining the Ganges and Brahmaputra-Jamuna flow was created, and this river then moved eastward to capture the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

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 Ganges channel is clearly defined for the purpose of this study by the international border and the Jamuna confluence. The channel is relatively old, and most of its charlands are bounded by embankments on both banks (Figure 1.2). While there are large chars in the Ganges, the present day low flows make it difficult to distinguish between attached and island chars. The Survey of Bangladesh 1:50,000 scale maps, 1989 SPOT satellite images at 1:50,000 scale, and the 1993 Landsat image were used to determine the study area and its characteristics.

Since the charland inventories for the Jamuna and Padma were undertaken before the surveys of the Ganges, the limits of the study area at the confluence had already been defined. The Brahmaputra-Jamuna and Padma inventories covered a short stretch of both banks of the Ganges by the Jamuna confluence. The downstream end of the Ganges study area, therefore, is Sujanagar Thana (Figure 1.3) and includes small areas of Bera and Rajbari thanas.

At the time of partition in 1947, the upper half of the Ganges course covered in this study constituted the boundary between India and Pakistan. The river subsequently altered course as meanders moved. The southern boundary of the study area, then, is the Indian border starting from a point in Daulatpur Thana where it joins the Ganges charlands, west to the furthest point of Shibganj Thana (the western extremity of Bangladesh). The changes that have occurred over time in the river course have created special problems both for this study and for border demarcation. In general there is very little land within Bangladesh on the right bank of the upper reach. For the inventory the international border was taken as the boundary and the Bangladesh Rifles, which patrol the border, were consulted to determine which mauzas were within the border. For morphological analysis using the satellite images, however, trends in the whole river course from the western end of Shib-

EVOLUTION OF THE RIVER SYSTEM OF BANGLADESH



Historic Figure I

ISPAN FAP 19, Geographic Information System

GANGES STUDY AREA BASE MAP

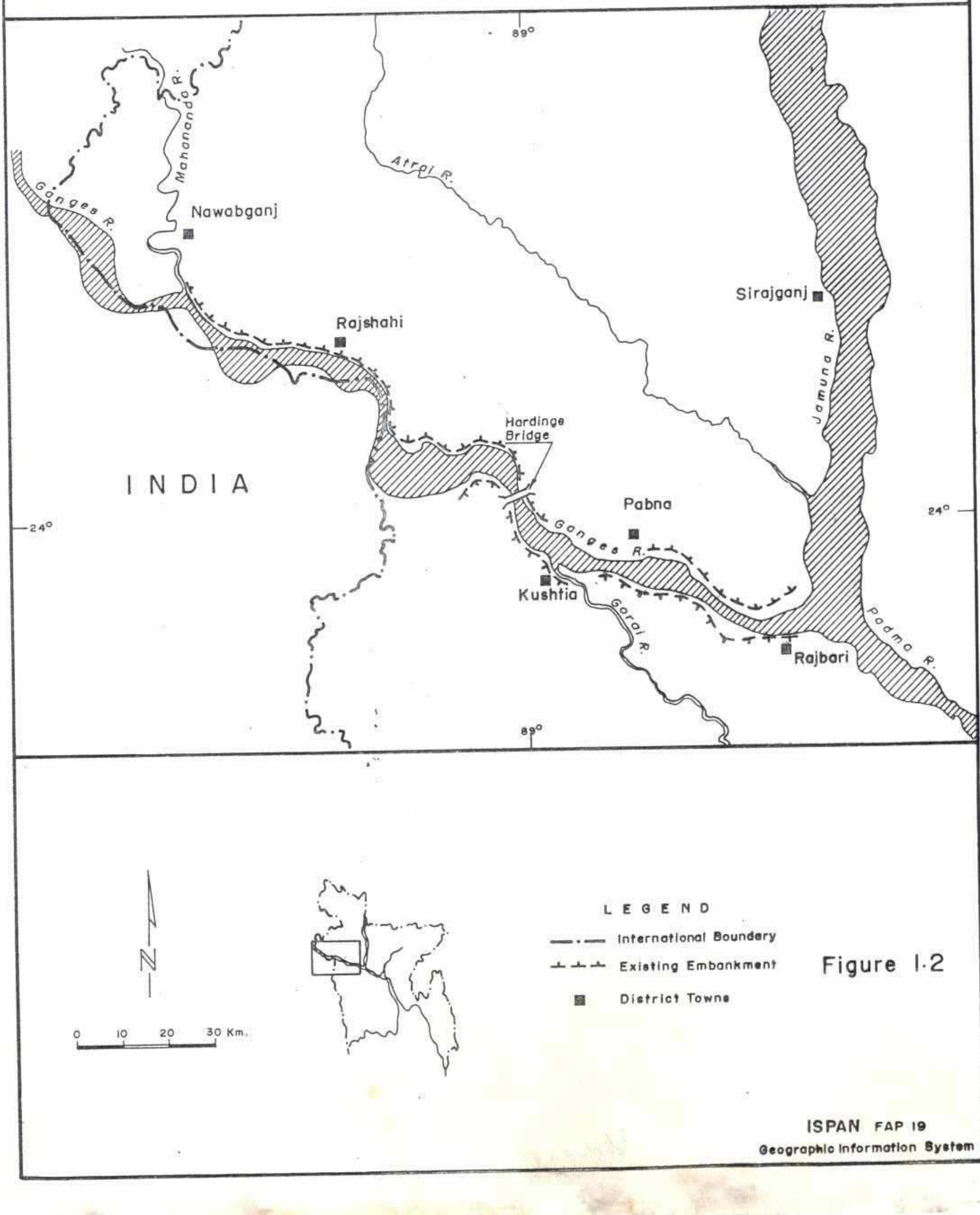
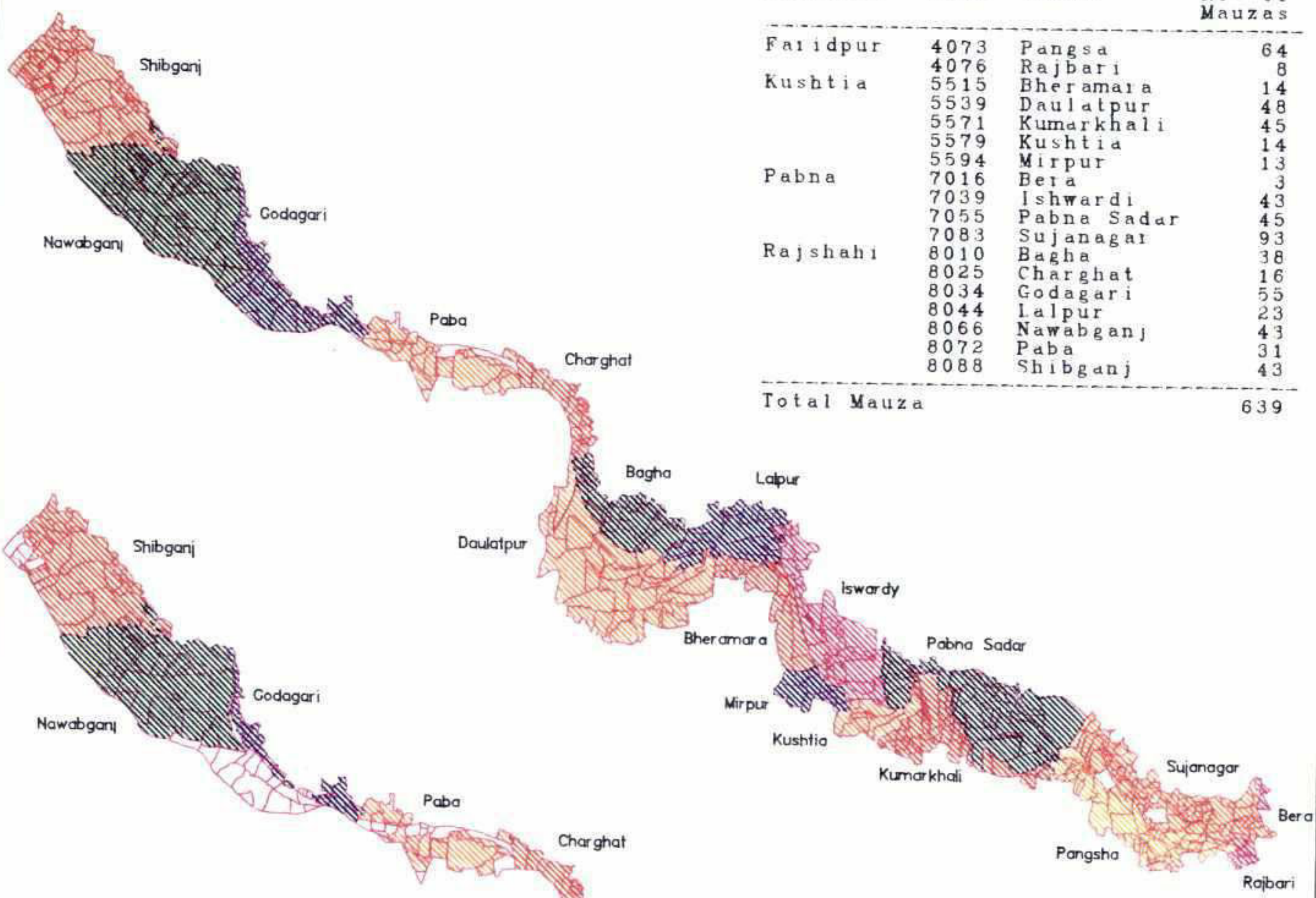


Figure 1.2

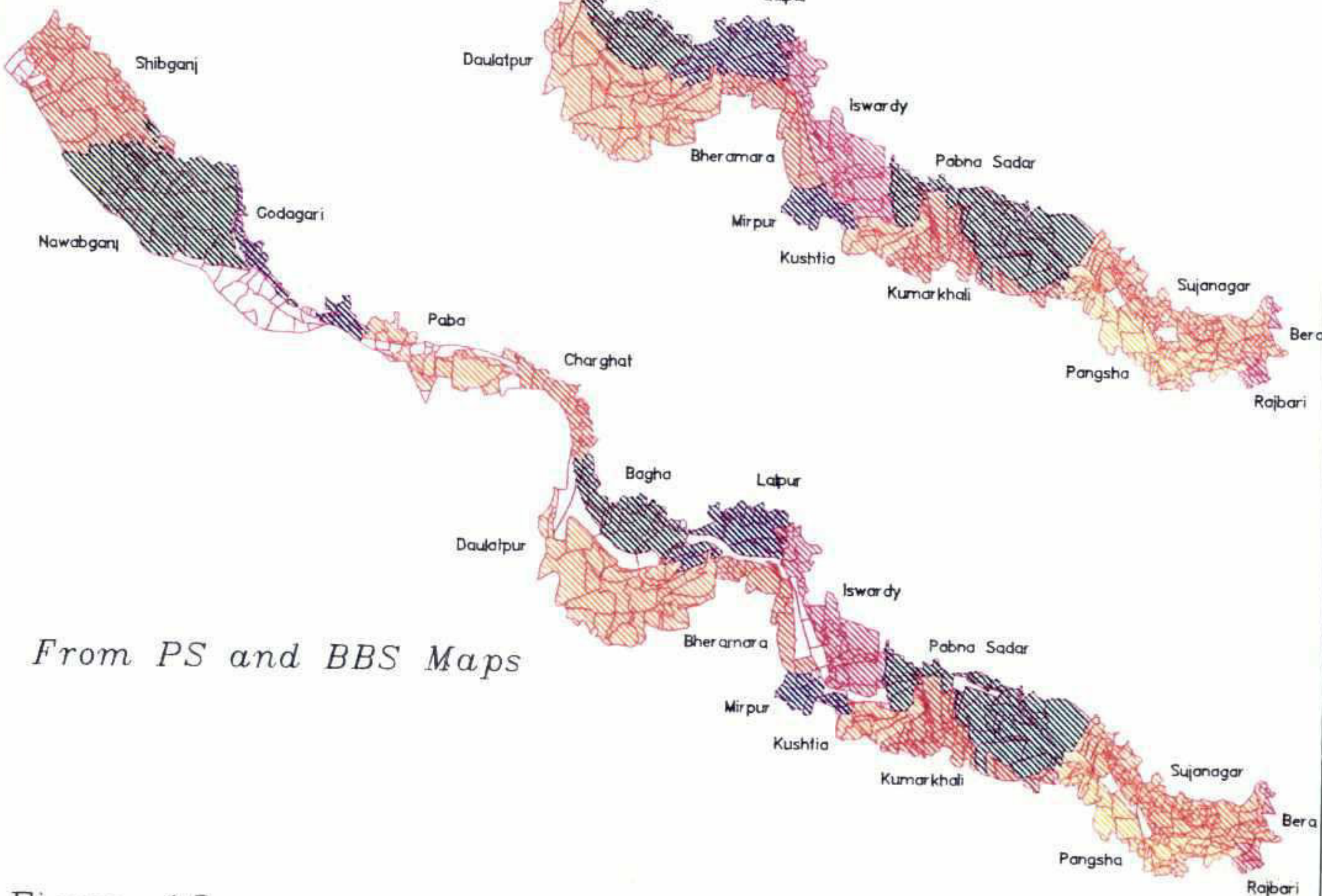
Ganges Reach Thanas

After Inventory Survey



NUMBER OF MAUZAS IN STUDY AREA BY THANA

District	Code	Thana	No. of Mauzas
Faridpur	4073	Pangsa	64
	4076	Rajbari	8
Kushtia	5515	Bheramara	14
	5539	Daulatpur	48
	5571	Kumarkhali	45
	5579	Kushtia	14
	5594	Mirpur	13
Pabna	7016	Bera	3
	7039	Ishwardi	43
	7055	Pabna Sadar	45
	7083	Sujanagar	93
Rajshahi	8010	Bagha	38
	8025	Charghat	16
	8034	Godagari	55
	8044	Lalpur	23
	8066	Nawabganj	43
	8072	Paba	31
	8088	Shibganj	43
Total Mauza			639



From PS and BBS Maps

Figure 1.3

ISPAN FAP-19 Geographic Information System ganj Thana eastward have been investigated since movement of the river course in nearby India is relevant to the Bangladesh charlands.

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

Along the west or south bank (right bank) of the Ganges there is an almost continual flood protection comprising both BWDB and local government embankments. FAP 4 has surveyed these embankments, and a copy of this map was used in delineating the study area. The Gorai offtake is still open, permitting the passage of flood water through the adjacent floodplains, and an area of charland between the Ganges and Gorai that is reported to be regularly flooded was included in the inventory. In Daulatpur Thana the formal embankment ends and local roads were used as approximate boundaries, but whole mauzas were surveyed in this area.

On the east or north bank (left bank) of the Ganges a continual embankment exists from the downstream end of the study area as far west as Godagari Thana, where it is tied into higher land by the Mahananda River. Upstream of this point the active Ganges floodplain, including flood spill channels, can clearly be seen in satellite images and is not very extensive. All mauzas in the active floodplain area of Nawabganj and Shibganj thanas were included in the study. Where no embankment existed the study area boundary was adjusted to follow mauza boundaries in order to simplify data collection for the inventory surveys.

The study area was divided into three reaches coinciding with differences in the study area boundary and types of chars. The upper reach covers all of the river bounded by the international border. Here the right bank area is minimal, but there is a large area of north (left) bank unprotected mainland. The middle reach covers a large area of island chars upstream of the Hardinge Bridge and the main area of unprotected mainland on the south (right) bank. The lower reach, downstream of Hardinge Bridge is the most confined, with embankments along both banks. Union parishad boundaries were followed in defining the limits of reaches to facilitate use of the inventory.

1.2.2 Links with Other FAP Studies

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

- Northwest Regional Study (FAP 2) and (BWDB, 1991)—embankment alignments along the north bank of the Ganges; and
- Southwest Regional Study (FAP 4)—survey of embankments along the south bank of the Ganges, plus historic maps and banklines of the Ganges-Padma and assessment of morphological change.

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 Ganges charlands. If a feasibility study for a Ganges barrage is ever undertaken, the charland inventory covers all of the mauzas that might be inundated by stored water, and would provide an invaluable database for such a study.

In addition, the Flood Modelling and Management Study (FAP 25) provided details of flood levels and return periods at gauging stations along the Ganges. The study also modelled possible impacts of proposed embankments on flood levels.

Potential further uses and users of the Ganges 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 Ganges 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 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 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

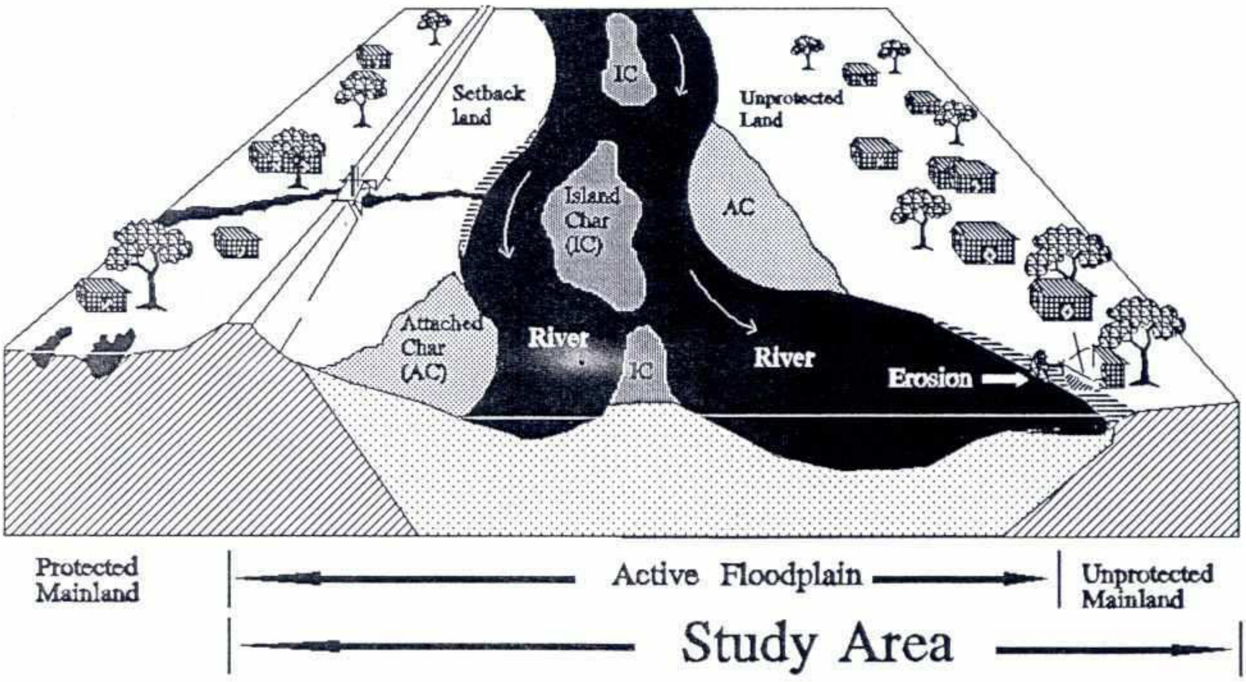


Figure 1.4 Charland Classification

during the peak of a "normal" flood (normal monsoon). Setback land is mainland on the river side of flood protection embankments, it differs from other unprotected mainland because the embankments may provide refuge during floods but may also constrain flood water, thereby raising flood levels. Unprotected mainland has no embankment between it and the main river and is inundated during higher than normal floods. Unprotected mainland has been surveyed up to the extent of recent floods or features, such as roads, that restrict flooding.

In the Ganges charlands most of the unprotected mainland in the middle and lower reaches is setback land. Elsewhere there are no plans for new embankments, so the land will remain unprotected. For consistency with the other charland inventory reports the term unprotected mainland is used for both categories of land.

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 Ganges. Categorization was based on the March 1993 satellite image, but since dry season flows are much lower than monsoon flows, in the dry season many channels show as bare sand in the image. At that time of year it is possible to walk from chars to the mainland, although these areas were islands in July 1993 when the inventory surveys were carried out.

Consequently, chars separated from the mainland by channels that are part of the main Ganges flow, and were water for most of their length in March 1993, were treated as island chars, even if the channel appeared in the image to have dry areas.

The constrained nature of the Ganges floodplain means that much of the area on the river side of the embankments is char, and in many cases there is little difference between attached and island chars, unlike in the other rivers studied.

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 Ganges most of these were surveyed between 1914 and 1916 and 1919 and 1924. Most were last revised in the 1930s and 1950s; a few were surveyed between 1940 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 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.[3] 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 many 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. Problems encountered in these areas are detailed in Section 1.3.5.

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 of existing and proposed embankments provided by BWDB 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 boundaries and study area boundary were then overlaid on the March 1993 Landsat image of the Ganges. 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 copies of the image and a mauza boundary map. They 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. 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 Ganges study area there were only nine mauzas where two inventories were completed.

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 India-Bangladesh border, originally defined as the middle of the Ganges, posed special problems for the inventory. Since the river has moved since the boundary was drawn and continues to do so, the border is difficult to define from physical features. Fortunately, the leader of the consultant team employed to carry out the inventory fieldwork was previously responsible for the annual river and demarcation surveys along the Ganges. This proved valuable in planning the fieldwork and obtaining permission from the Bangladesh Rifles to work in these areas.

The main fieldwork problems involved mauzas not shown in the Police Station maps or in the BBS Small Area Atlas (although listed in the latter), and mauzas and charland that, although inhabited, were not included in any secondary sources. Figure 1.3 compares the thana and mauza coverage of the study area available from sources in Dhaka prior to the fieldwork (bottom in the figure) with the map completed by the fieldwork team (top in the figure). The map based on available information was provided to the survey team at the start of fieldwork. White spaces in that map are either areas where the mauzas had not been mapped, or *khas* land that has not been allocated to a mauza. The inventory therefore had to compile mauza boundaries in many areas to enable the data to be analyzed and mapped using the GIS.[4]

Mauza, thana, and district boundaries in the study area had mostly been fixed by 1914-20, and they have only been slightly modified since then, 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 in parts of the middle and lower reach following what once was the center of the river.

Figure 1.3 also does not show many smaller changes in mauza boundaries reported to have taken place, such as mauzas that had been extended as land accreted. There were 104 mauzas that were either added to the database or for which boundaries had changed since the Police Station maps were surveyed (16 percent of mauzas in the final Ganges GIS).

In the field maps used for the inventory, uncertain or missing mauza boundaries were identified. As part of the inventory survey, the field teams consulted union parishad chairmen and members, informed local people, and local surveyors (*amin*) about boundaries. This information was cross-checked with information and maps from the Assistant Commissioner (Land), the local settlement office, and/or the thana revenue office and Thana Nirbahi Officer, before it was used to fill in current mauza boundaries on the base maps. The field teams collected maps from the relevant thana land record offices to support any changes to the maps, but they were neither set up nor equipped to carry out detailed surveys for new mapping.

Some problems encountered by the fieldwork are:

- in Shibganj, as the Ganges has moved and chars have formed on the both sides of the river, mauzas have been extended and new mauzas created. In addition, one mauza was in this area and not in a mainland area, as shown in the existing maps;
- In Nawabganj the boundary of one mauza is disputed with India;
- none of the 10 mauzas of Char Ashariadaha Union in Godagari Thana were shown in the Police Station map or Small Area Atlas;
- the mauzas of Gargari Union in Bagha Thana have disputed boundaries between the districts of Natore and Kushtia; and
- there are large areas of *khas* land in the chars that are seasonally used but not permanently settled on the border of Bagha and Daulatpur thanas, these were included in the inventory.

In many mauzas bordering newly accreted chars, the effective area of the mauza has been extended and the people use the new land. Although this may not be officially recognized in all cases, boundaries have been revised in the GIS so that the inventory data is related to an approximation of the correct area.

All of the confusions and lack of reliable spatial information and accurate maps for the Ganges charlands mean that there is uncertainty about the location and distribution of resources and people relative to administrative units. This must handicap efficient administration and development planning. Official boundary demarcation is required in the areas where this study found boundaries to be unmapped, uncertain, or disputed. This will ensure that the spatial content of census data is correct and that government officers and elected representatives have accurate information about their service areas and constituents.

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 March 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 charlands in this study have been defined to include not only island chars but also the mainland areas referred to as active floodplain in World Bank (1989).

2. For all maps included in this report, the international boundary has been derived from available map sources; the boundary is approximate, and should not be taken as authoritative.

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

4. The lower map was based on information available prior to the survey and shows mauza boundaries which were derived from the fieldwork within the white spaces.

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, as well as the 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 Ganges has changed little since 1984, all sections of the river have been quite dynamic. The Ganges 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 widened considerably, except in the area west of Charghat where mainland has accreted causing a constriction of the channel. The middle reach has also widened significantly, especially along the outer bank of the meander south of Charghat. The southeastern section (lower reach) maintained its width and planform over most of its length, except just upstream of the Ganges-Jamuna confluence where the river shifted southward and narrowed considerably. Additionally, the area of charland in the upper and lower reaches increased dramatically. The overall increase in within-channel land area was compensated for by the loss in mainland due to bankline erosion. The channel adjacent to Hardinge Bridge remained essentially static throughout the study period.

The Ganges has followed its present course in Bangladesh for at least 500 years, and therefore, its channel should be in dynamic equilibrium with upstream flow and sediment regimes. The river downstream of Hardinge Bridge has, however, evolved from a meandering to a braided pattern. Recent satellite images, though, show the development of a more sinuous course again in the upper and middle reaches, bringing rapid bank erosion at meander bends. The width of the upper and middle reaches will likely continue to increase as floodplain is eroded, and sedimentation will continue to enlarge existing chars and create new ones at meander bends. Analysis of a longer time series of images would make quantitative predictions of future trends possible.

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 Brahmaputra are the larger, both ranking among the top 10 rivers in the world. The Upper Meghna is much smaller and mainly drains the Sylhet basin of Bangladesh, but just north of Chandpur it is joined by the Padma (the combined Ganges and Brahmaputra flow). The Lower Meghna carries most of the flow of these great rivers into the Bay of Bengal. When considering the present hydrology and geomorphology of these rivers and the alluvial fan they continue to build, it is important to bear in mind their dynamic nature over both the geological time scale and the recent past.

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. Until that time, there had been no confluence of the Ganges with either the Brahmaputra or the Meghna rivers, but this situation was to change radically in the next few years.

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 that took the it 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 of these rivers entered the Bay of Bengal along the present course of the 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 large bend so produced is still in evidence and tends to migrate eastward.

The Ganges today is a very large watercourse, draining a catchment area of about 1,070,000 km^2 (Rogers *et al.*, 1989). The river's average discharge of about 11,800 cumecs and bankfull discharge of about 45,000 cumecs, make this the eighth 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 occurs in late August or early September.

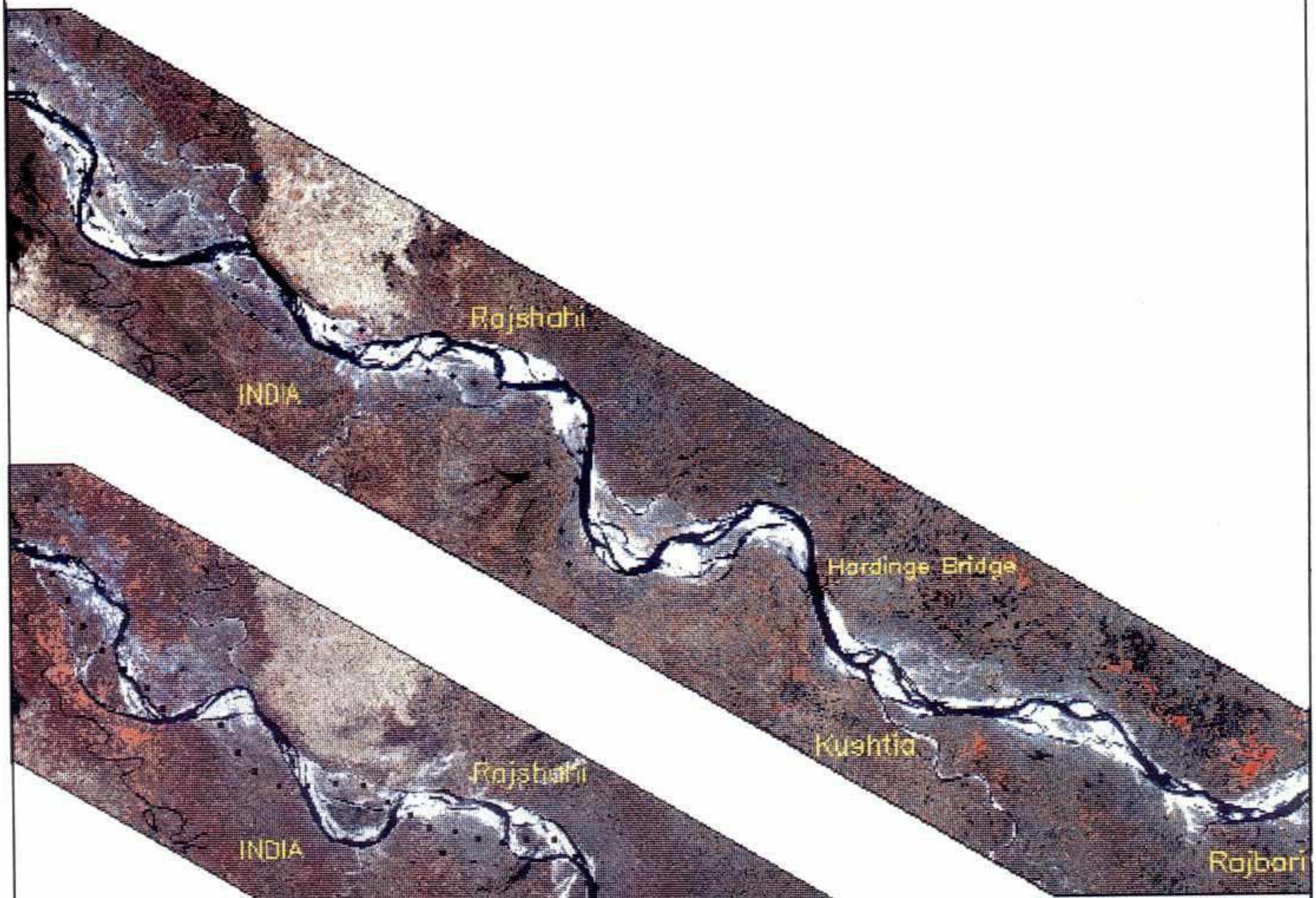
During the long winter dry season the Ganges has a comparatively low discharge due to upstream regulation and abstraction of water in India. In the last two decades the dry season flow has dropped markedly. The March average flow at Hardinge Bridge for 1989-92 was 576 cumecs, which is only 25 percent of the 1934-74 average, and 50 percent of the 1975-88 average (FAP 4, 1993). This has implications for the charlands, as well as serious environmental impacts in the southwest region (discussed in FAP 4, 1993). Right bank distributary off-takes such as the Matabhanga and Gorai-Madhumati are important regional rivers whose water supply may also be threatened.

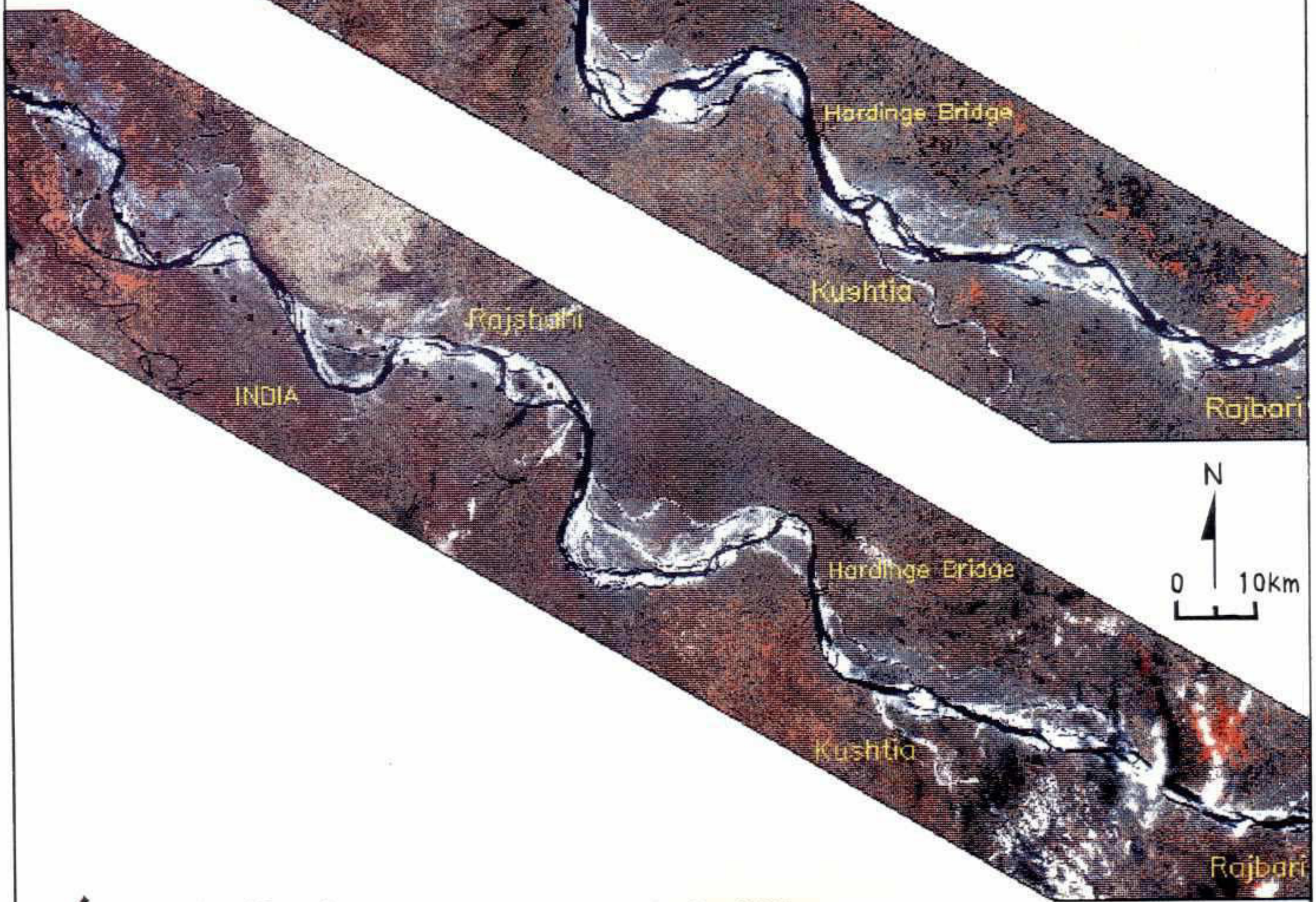
The basins of both the Ganges and Brahmaputra are bounded by the highest and most tectonically active mountain range in the world, the Himalayas. These young alpine mountains are naturally subject to severe erosion resulting in heavy sediment loads in the Ganges. Moreover, land use changes in the foothills of the Himalayas have

Figure 2.1 1984 DRY SEASON SATELLITE IMAGE

Source: ISPAN, Landsat TM image

International Boundary





International Boundary

Source: ISPAN, Landsat MSS image.

Figure 2.2 1993 DRY SEASON SATELLITE IMAGE 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 estimated annual sediment load of the Ganges is around 450 million tons per year (FAP 4, 1993).

The large and variable flow, coupled with a high sediment load, results in a complex and dynamic wandering river. The Ganges changes 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 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).

Data from two Landsat satellite sensors were used: the Multi-Spectral Scanner (MSS) 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, resampled 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 the extent of the study area, which includes the entire Ganges River within Bangladesh excluding the Ganges-Jamuna confluence, an area approximately 110 km north-south by 165 km east-west (Figures 2.1 and 2.2).

Table 2.1 Satellite Imagery Used for the Meghna Char Study

Date	Path/Row	Sensor
March 19, 1984	138/43	MSS
March 11, 1993	138/43	TM

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) and used for similar analyses in the Jamuna study. 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 1993 image was partially obscured by clouds along the southeastern (lower) reach of the river and in the vicinity of Rajshahi. Consequently, clouds and their shadows were initially categorized by the classification. Cloud-affected areas then had to be manually re-classified by editing the digital image on-screen. Unfortunately, it was not possible to reliably distinguish between cultivated and naturally vegetated land in the cloud-covered areas using this method, but water and sand were identified with sufficient accuracy. The final product was an image composed of three land cover classes: water, sand, and cultivated/vegetated land.

2.3.4 Accuracy Assessment of Image Classification

The accuracy of the March 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 15 sites on the river banks and chars of the lower reach. For each site a polygon was depicted on 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 ground truth site. There were a total of six land cover classes corresponding to types of cultivated land (cropped and emerging crop or fallow), natural vegetation (homestead and catkin), 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. Cultivated and natural vegetation classes were combined for this analysis since they have similar meanings in the context of this study, and were not clearly distinguishable due the less than optimal image quality described above. As a result, a simple three-category classification was used in the remainder of this study.

Accuracy was determined according to the percentage of ground truth sites correctly classified. Table 2.2 summarizes the results and shows that overall classification accuracy was 92 percent. The two most accurate classes were cultivated/vegetated land, for which the image classification was 100 percent accurate, and water, which was 97 percent

Table 2.2 Comparison of 1993 Image Classification with Verified Land Type

	Field-Verified Area		Classified Correctly		Classified Incorrectly	
Land Type	Area (ha)	%	Area (ha)	%	Area (ha)	%
Water	19.0	18	18.5	97	0.5	3
Sand	38.3	36	30.5	80	7.8	20
Cultivated/Vegetated	48.4	46	48.4	100	0	0
Total	105.7	100	97.4	92	8.3	8

Source: FAP 19 ground truthing

accurate. These exceptionally high values are not unusual for a three-category classification. Accuracy was lower for sandy areas, which can be confused with cultivated land (fallow or emerging crops). Cloud cover also contributed to the misclassification of sand, and some errors also may be attributed to the time lapse of three months between the time the image was taken and the field observations, to inaccurate responses from interviews, or to variability in sample areas.

Since the satellite image processing was initiated in 1993, it was impossible to perform an accuracy 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 comparison of changes in location over time. Detailed analysis of these changes between 1984 and 1993 is described below.

2.4 Riverbank Erosion and Accretion

2.4.1 Context

The wandering of the Ganges creates rapid bank erosion. Banks inside the geomorphologically active corridor comprise 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 Ganges. The assessment of historic trends in the morphology of the Ganges 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 Ganges 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 the reliability of those predictions. The image analysis results include the Indian side of the river along the Bangladesh border, since it is important to understand trends and processes in the whole river. Erosion is a problem on both sides of the river. Verghese (1990) reported that between 1931 and 1978, 28,000 ha of land were eroded on the Indian side downstream of Farraka, and an additional 1,700 ha eroded between 1978 and 1987.

2.4.2 Channel Morphology

The Ganges has followed its present course in Bangladesh at least since the 15th century and possibly longer, and has had 500 years or more to form its channel. There is reason to suppose, therefore, that it has had sufficient time to develop a channel adjusted to the range of flows and sediment loads from upstream inputs. In other words, the three-dimensional geometry of the channel may be in dynamic equilibrium with the flow and sediment regimes. If this is the case, the characteristics of present channel shifting should not be producing net changes in the gross form of the river and should give a reasonable indication of future trends, at least over short and medium time scales.

The flow regime is known to have been affected by upstream regulation, flood protection, and dry season water abstractions in India. Verghese (1990) refers to a large anti-erosion project along the Ganges being implemented by the West Bengal government. Also, river training at the Hardinge Bridge in Bangladesh has artificially fixed a point in the planform where the channel naturally would move laterally as part of planform change. These human impacts may generate a morphological response in the channel downstream by triggering complex process-response mechanisms linking channel form and processes.

FAP 4 (1993) analyzed the Ganges long-profile and records from the Hardinge Bridge gauging station. The results showed no sustained trends in water levels for specific discharges over the period of record since 1947, nor did there appear to be any trend in bed level. The dominant discharge of the river, 38,000 cumecs, corresponds to "barfull" discharge. This is a flow that just overtops channel bars but does not overtop the banks and inundate the floodplain. This correspondence of dominant and barfull flows indicates that the cross-section of the river is adjusted to the flow and sediment regime. In contrast, the planform pattern of the river has changed radically over the past 200 years and continues to change today, although unlike the Padma, the width and position of the geomorphologically active river corridor has remained relatively immobile.

As in the case of the Padma, the maps produced by FAP 4 have allowed an examination of historical and present patterns of planform change. The results, described in detail in the following sections, show that the river corridor has widened only slowly and not shifted significantly since 1779, although radical changes of planform pattern have occurred within the corridor. These changes are most marked downstream of the Hardinge Bridge site, where the large, sweeping meanders shown in Rennell's map have been replaced by a much straighter, more braided planform.

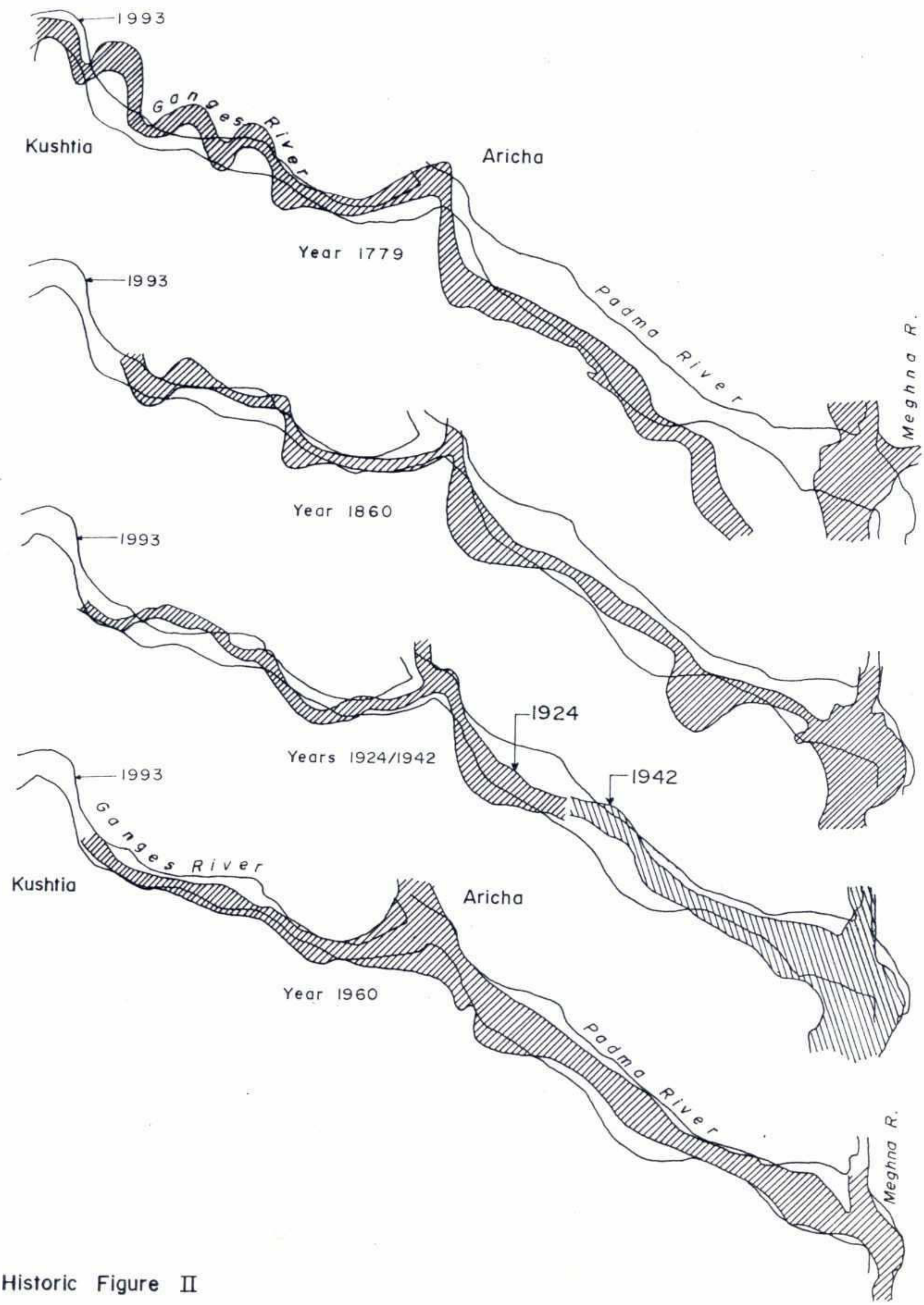
Analyses of historical maps (FAP 4) and satellite images (FAP 19) are described in detail in the following sections. These show that the river planform has varied between mainly braided, with a relatively straight alignment, and meandering, with very large, sweeping bends that swing from one side of 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 Ganges by digitally superimposing grids on the 1984 and 1993 image-derived banklines. Both north-south and northeast-southwest oriented grids were used so that all river cross-sections used for measurements were approximately perpendicular to the river.

In 1779 (red in the figure), the lower reach of the Ganges was predominantly a single-thread channel, although Rennell's map shows divided reaches where there were substantial chute channels behind the point bars in addition to the dominant discharge channel ("thalweg") that followed the line of the outer bank in most bendways. At that time, the axis of the meandering river was close to, but a little north of, its 1993 centerline, but the sweeping bendways took it alternately far to the north

HISTORIC BANKLINE POSITION OF THE GANGES — PADMA RIVERS

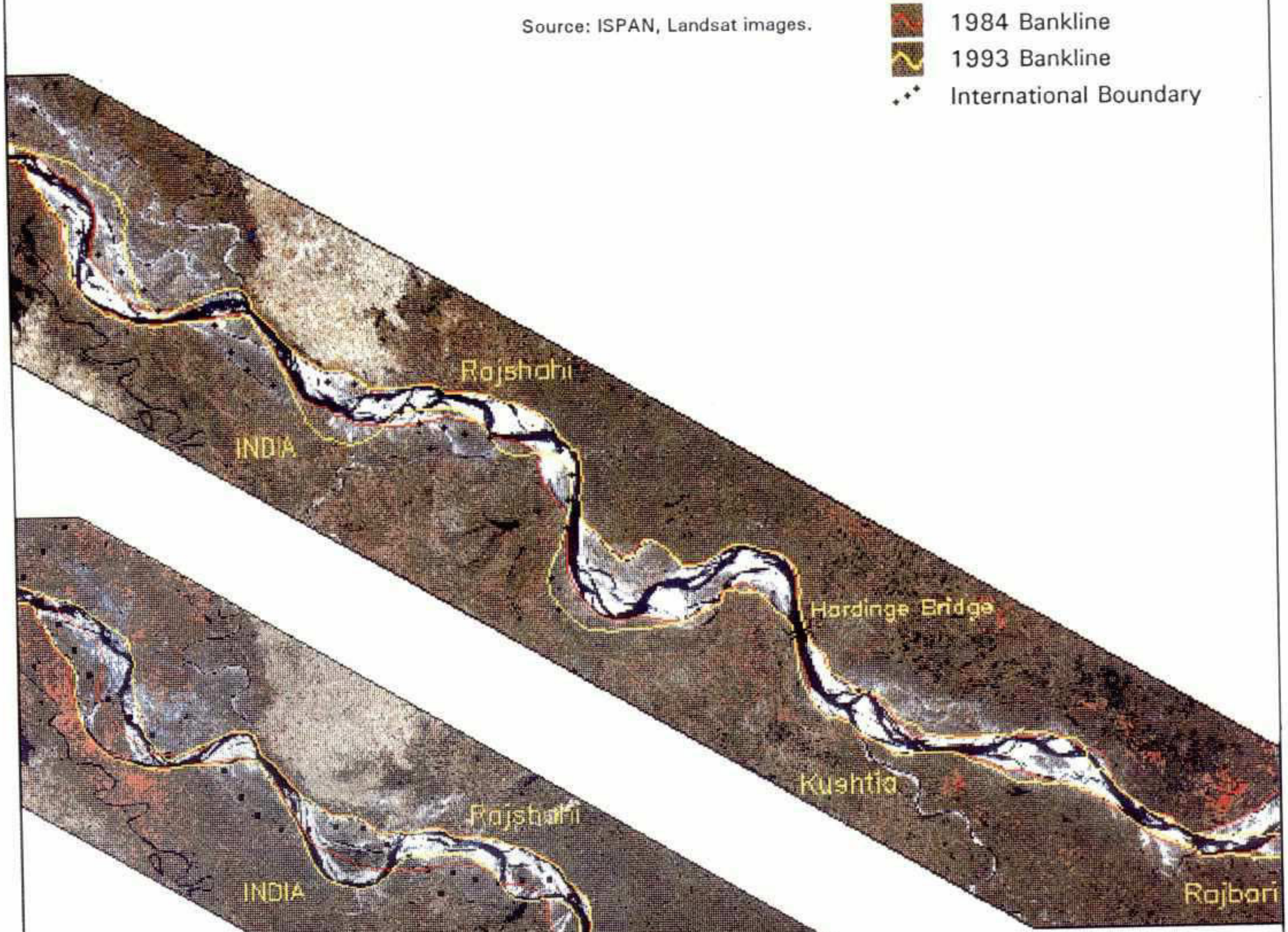


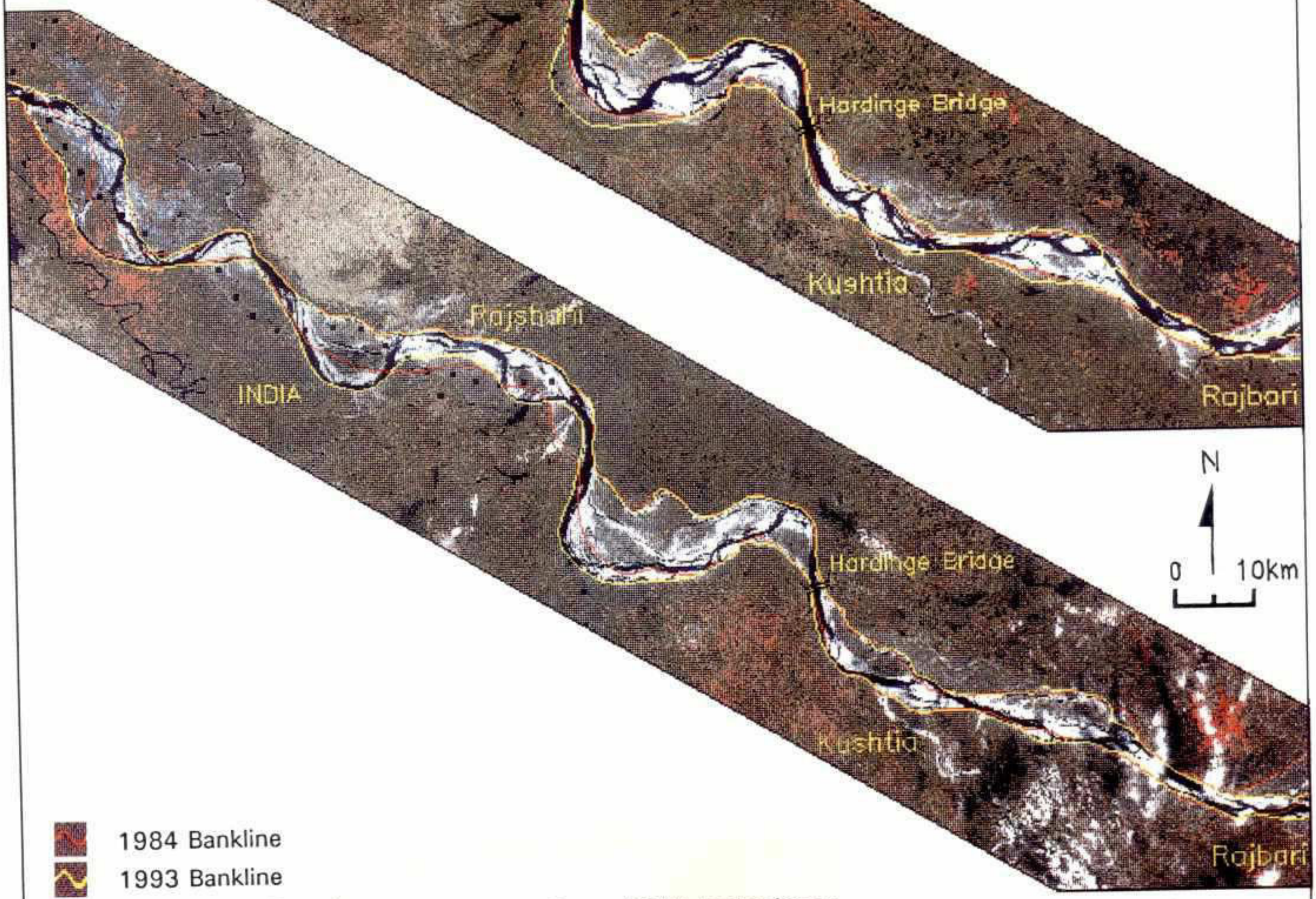
Historic Figure II

Source : FAP 4 and FAP 19

Figure 2.3 BANKLINE MOVEMENT: 1984 IMAGE

Source: ISPAN, Landsat images.





Source: ISPAN, Landsat images.

Figure 2.4 BANKLINE MOVEMENT: 1993 IMAGE and south of the axis, cutting vast embayments into the floodplain on either side of the channel. Its history since then has been dominated by a reduction in sinuosity and increased braiding, although recently there are signs of renewed meandering tendencies.

Two and a half very large meanders are visible in the map of 1779, producing five bendways downstream of the Hardinge Bridge site. The first bend is at Talbaria (Kushtia), close to the off-take of the Gorai River. Almost symmetrical meanders with a wavelength of around 35 km then extend downstream to the off-take of the Chandina River.

By 1860 (green in the figure), the third bend had been abandoned by a chute cut-off, so that the planform had two meanders separated by a straight reach. In the remaining bends, the chute channels appeared to have enlarged, suggesting that the meandering tendency was waning during this period.

The 1924/42 map (blue in the figure) reveals further chute cut-offs and loop abandonment. None of the five bendways visible in 1779 was still present, but the planform remained somewhat sinuous due to residual meandering through chute channels that were offset on opposite sides of the valley axis.

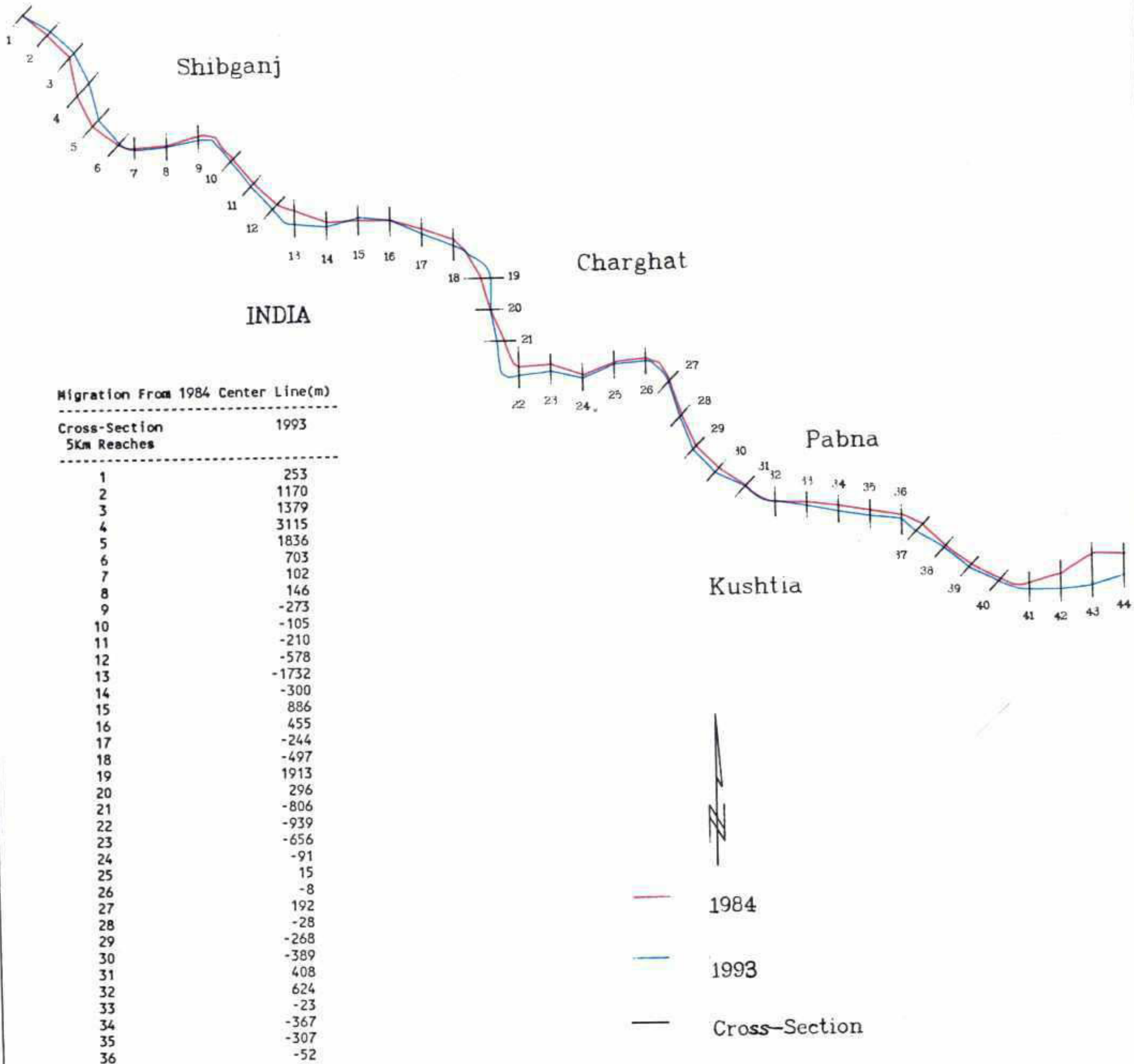
By 1960 (yellow in the figure), straightening had proceeded to the point where the sinuosity of the 1779 channels had all but disappeared. In its place, the main river displayed a series of long radius, low curvature bends with a wavelength perhaps double that of the 1779 meanders.

This pattern persists in the 1984 and 1993 banklines, the only ones based on satellite imagery (Figures 2.3 and 2.4). This data source allows a much more detailed examination of planform pattern as the low-flow channels, high-flow chutes and back sloughs can be examined. The 1993 banklines suggest a tendency toward more braiding than was evident in 1960, although this may be partially explained by the better resolution of image-based mapping. The latest images hint at the re-establishment of a meandering low-water channel that may be growing in sinuosity and tending to re-occupy back channels in the embayments left by the meanders shown in the 1779 map. In this case, renewed bank erosion along the outer banks of at least some of the embayments might be expected in the medium term.

Image analysis of the dry season river channel revealed that between 1984 and 1993 there was little significant movement of the channel centerline. Only in the vicinity of the more acute meanders in the upper and middle reaches did significant amounts of erosion or accretion occur. Centerline movements were approximately 3 km north at Shibganj and 2 km south on the bend southeast of Shibganj (Figure 2.5). Close to Charghat the centerline also meandered significantly, with movements up to 2 km east and southwest near cross-sections 19 and 22, respectively. The river remained stationary in most of the lower reach with the exception of the area just upstream of the Jamuna confluence, where the centerline shifted as much as 4.7 km south (mainly due to north bank accretion). This shift translates to an annual movement exceeding 500 m. On the other hand, the effects of river training at the Hardinge Bridge are apparent at cross-section 28, where the centerline shifted only 28 meters.

Overall, the maps indicate that the axis of the channel between Hardinge Bridge and Goalando (lower reach) has not migrated far in more than 200 years, and the southeast trend of the river is maintained throughout. The present course of the river is perhaps slightly to the south of the 1779 position, but the gross change in planform configuration from meandering to braided makes such a comparison of doubtful value. The main conclusion is that the river has straightened its course and increased its gradient in the past two centuries, but may now be showing some evidence of re-establishing a more sinuous course again. Cyclical planform changes like this are the hallmark of a wandering river as it hunts for a nonexistent equilibrium planform in the transitional region between single-thread meandering and multi-thread braiding.

Center Line Migration (1984–1993)



Migration From 1984 Center Line(m)

Cross-Section 5Km Reaches	1993
1	253
2	1170
3	1379
4	3115
5	1836
6	703
7	102
8	146
9	-273
10	-105
11	-210
12	-578
13	-1732
14	-300
15	886
16	455
17	-244
18	-497
19	1913
20	296
21	-806
22	-939
23	-656
24	-91
25	15
26	-8
27	192
28	-28
29	-268
30	-389
31	408
32	624
33	-23
34	-367
35	-307
36	-52
37	-899
38	234
39	32
40	127
41	-642
42	-2122
43	-4720
44	-2845
Mean	-119

Figure 2.5

ISPAN
FAP19 Geographic Information System

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

Reach		Year	Average	Maximum	Minimum
Upper		1984	3.81	5.79	1.73
		1993	4.67	10.11	1.68
	Change		+0.86	+4.32	-0.05
Middle		1984	6.04	10.07	1.90
		1993	6.35	11.69	1.67
	Change		+0.31	+1.62	-0.23
Lower		1984	4.33	8.24	1.82
		1993	3.64	6.91	2.04
	Change		-0.69	-1.33	+0.22

Sources: 1984 and 1993, Landsat images

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 channel widths and bank erosion rates between 1984 and 1993.

Channel width statistics are summarized in Table 2.3, where positive values were assigned for net widening and negative values for net narrowing. In 1984, the average width of the upper reach was 3.8 km, in the middle reach 6.0 km, and in the lower reach about 4.3 km. By 1993, the average width of the upper reach increased by about 0.9 km, while in the lower reach it decreased by about 0.7 km. The average width of the middle reach changed little over the nine years, but remained the widest of the three.

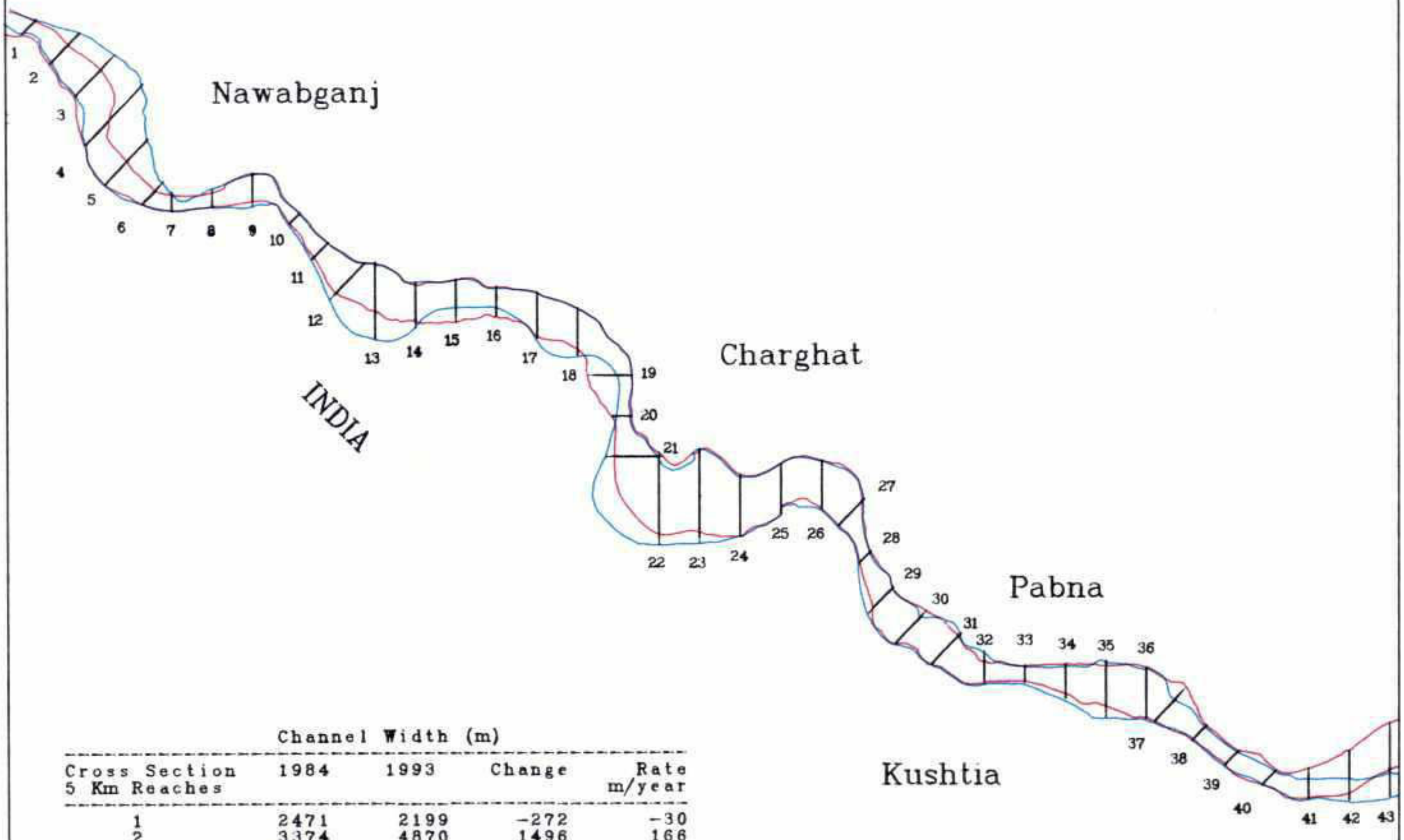
Trends in channel width since 1984 naturally followed the same general patterns as those exhibited by the centerline analysis, with significant changes occurring at acute bends in the river (Figure 2.6). Changes in channel width result from the net shift in opposing banklines. Since 1984, most changes in the width of the Ganges in any given area resulted from shifts in one bank. Banklines in the upper reach near Nawabganj shifted up to 6 km northeast (cross-section 4) and 3.5 km south (cross-section 13). The banklines also moved more than 3 km on both meander bends east of Charghat. Bankline changes near the confluence with the Jamuna were dramatic: the left and right banks shifted 6 km and 3.3 km to the south, respectively, causing significant narrowing of the channel. Finally, the river training works at Hardinge Bridge minimized left bank shifts to only 90 m and right bank shifts to 146 m away from the channel centerline.

Channel widening was greatest in the upper reach where increases of 5.7 km and 3.6 km were measured at cross-sections 4 and 13, respectively (Figure 2.6). Likewise, the most notable constriction of the Ganges occurred in the upper reach, where it narrowed by 3.8 km west of Charghat (cross-section 19). Significant reductions in channel width were also measured at cross-sections 15 and 16. In the middle reach the channel widened up to 3 km in the bend southeast of Charghat, where the river is attacking the right bank. The width increase of 236 m recorded near Hardinge Bridge is based on images from times of low flow, when width variations near the bridge are entirely plausible. The width of the river in the lower reach has been relatively stable since 1984 except near the Jamuna confluence where the channel narrowed as much as 2.7 km.

Bankline erosion took more than twice the area accreted along the Ganges between 1984 and 1993 (Table 2.4). Accretion was high compared to the Meghna and Padma rivers, where the equivalent

Bankline Positions and Width

(1984–1993)



Channel Width (m)

Cross Section 5 Km Reaches	1984	1993	Change	Rate m/year
1	2471	2199	-272	-30
2	3374	4870	1496	166
3	4670	6854	2184	243
4	4378	10110	5732	637
5	3946	7650	3704	412
6	2260	3669	1409	157
7	1920	2345	425	47
8	1726	2195	469	52
9	3323	4079	756	84
10	1737	1850	113	13
11	2487	2804	317	35
12	4997	6150	1153	128
13	5794	9387	3593	399
14	4418	5597	1179	131
15	5295	3368	-1927	-214
16	3746	2282	-1464	-163
17	5396	5740	344	38
18	5001	5854	853	95
19	5479	1682	-3797	-422
20	2420	1672	-748	-83
21	6012	6546	534	59
22	9970	10871	901	100
23	10073	11693	1620	180
24	7578	7411	-167	-19
25	6230	6189	-41	-5
26	5984	6031	47	5
27	4177	4591	414	46
28	1900	2136	236	26
29	3652	4455	803	89
30	5524	4622	-902	-100
31	4829	5101	272	30
32	2669	3908	1239	138
33	1819	2064	245	27
34	3690	4088	398	44
35	4933	6913	1980	220
36	6206	6117	-89	-10
37	5687	3722	-1965	-218
38	2541	2037	-504	-56
39	2375	2315	-60	-7
40	2485	2164	-321	-36
41	3608	2599	-1009	-112
42	5245	2843	-2402	-267
43	5768	3046	-2722	-302
Mean	4367	4693	326	36

1984

1993

Cross-Section

Figure 2.6

ISPAN

FAP19 Geographic Information System

bank erosion was 14 and 8 times the amount of accretion, respectively. This trend of land formation is also evident in within-channel dynamics (Section 2.5).

Table 2.5 summarizes net erosion and accretion rates. The highest nine-year erosion rate for the cross-sections at 5 km intervals was 665 m per year on the left bank east of Nawabganj. Net erosion was greatest on the left bank of the upper reach, where the mean bankline shift was 850 m and the mean erosion rate was 94 m per year. In contrast, the left bank of the lower reach had net accretion (positive numbers), with a mean shift of 1,047 m and annual change of 116 m. Bankline erosion/accretion rates greater than 200 m per year were exceptional, occurring at less than 14 percent of the cross-sections.

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

Reach	Eroded Area (Ha)	Accreted Area (Ha)
Upper	12,491	4,543
Middle	5,116	1,144
Lower	2,552	3,398
Total	20,159	9,085

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

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 shifts in the channel at acute meanders in the upper and middle reaches appear even more dramatic from this perspective. This is because within-bank island chars located on the inner bank of these bends are sometimes morphologically more similar to attached chars. By considering them part of the channel, the width is increased, to give an approximation to the monsoon water flow (for which images are not available), rather than the dry season flow.

By concentrating on bank changes in the main channel, the complex changes in this 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 in the upper and middle reaches, where erosion was concentrated in the outer bends of two south bank meanders, and in Nawabganj where the river shifted eastward (red). Opposite Rajshahi and Rajbari, significant accretion and channel constriction took place (tan color). Table 2.4 shows that the area of net accretion was nearly 49 percent of the area of mainland lost to erosion (much more than in the other main rivers over the same period).

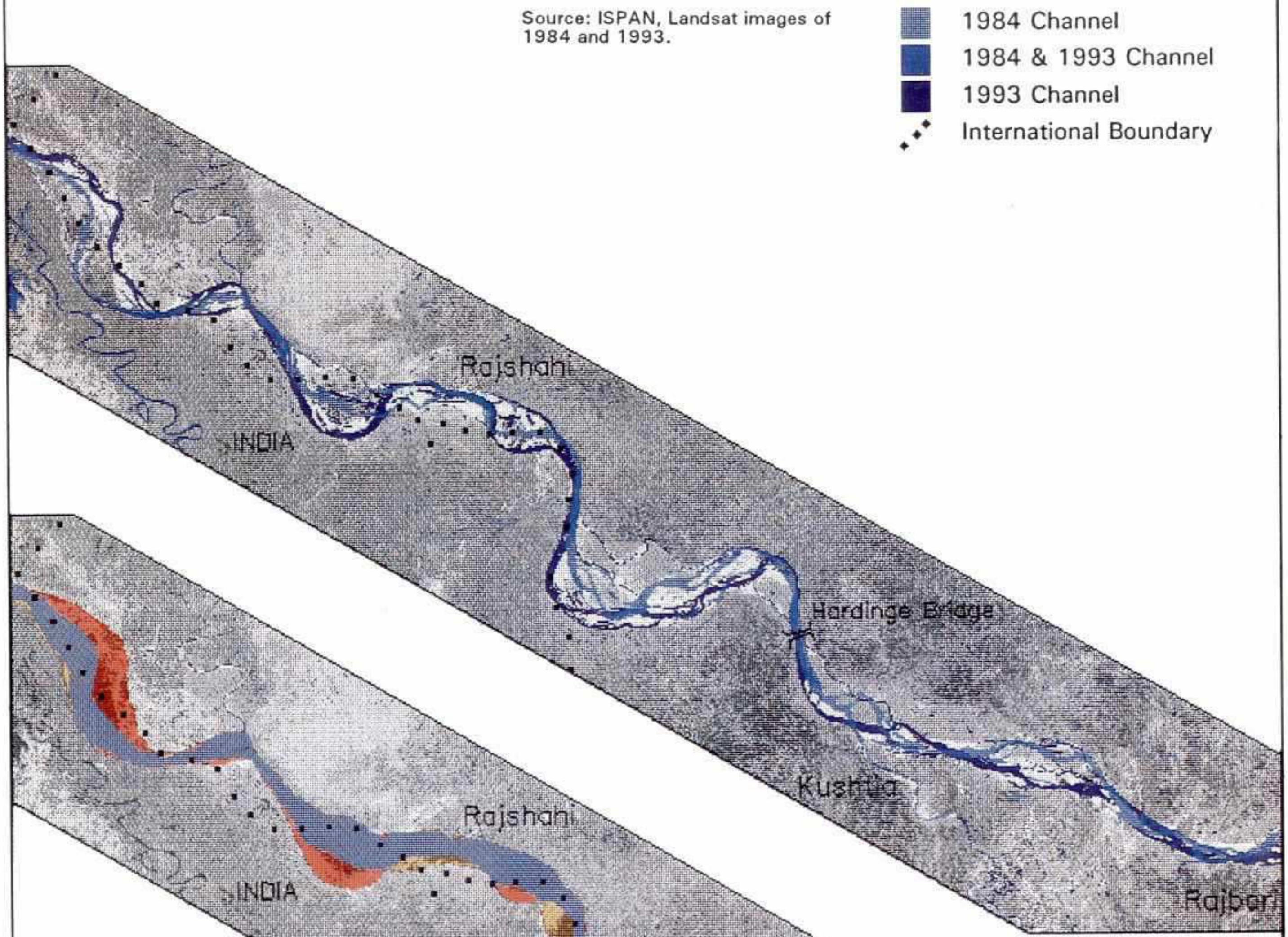
Table 2.5 Mean Bankline Erosion/Accretion Rates; 1984-1993*

Bank	Change	Upper	Middle	Lower	Total
Right	Shift 84-93 (m)	-6	-380	-354	-740
	Rate (m/yr)	-1	-42	-39	-82
Left	Shift 84-93 (m)	-850	70	1047	267
	Rate (m/yr)	-94	8	116	30

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

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

Figure 2.7 LOW FLOW CHANNEL MIGRATION



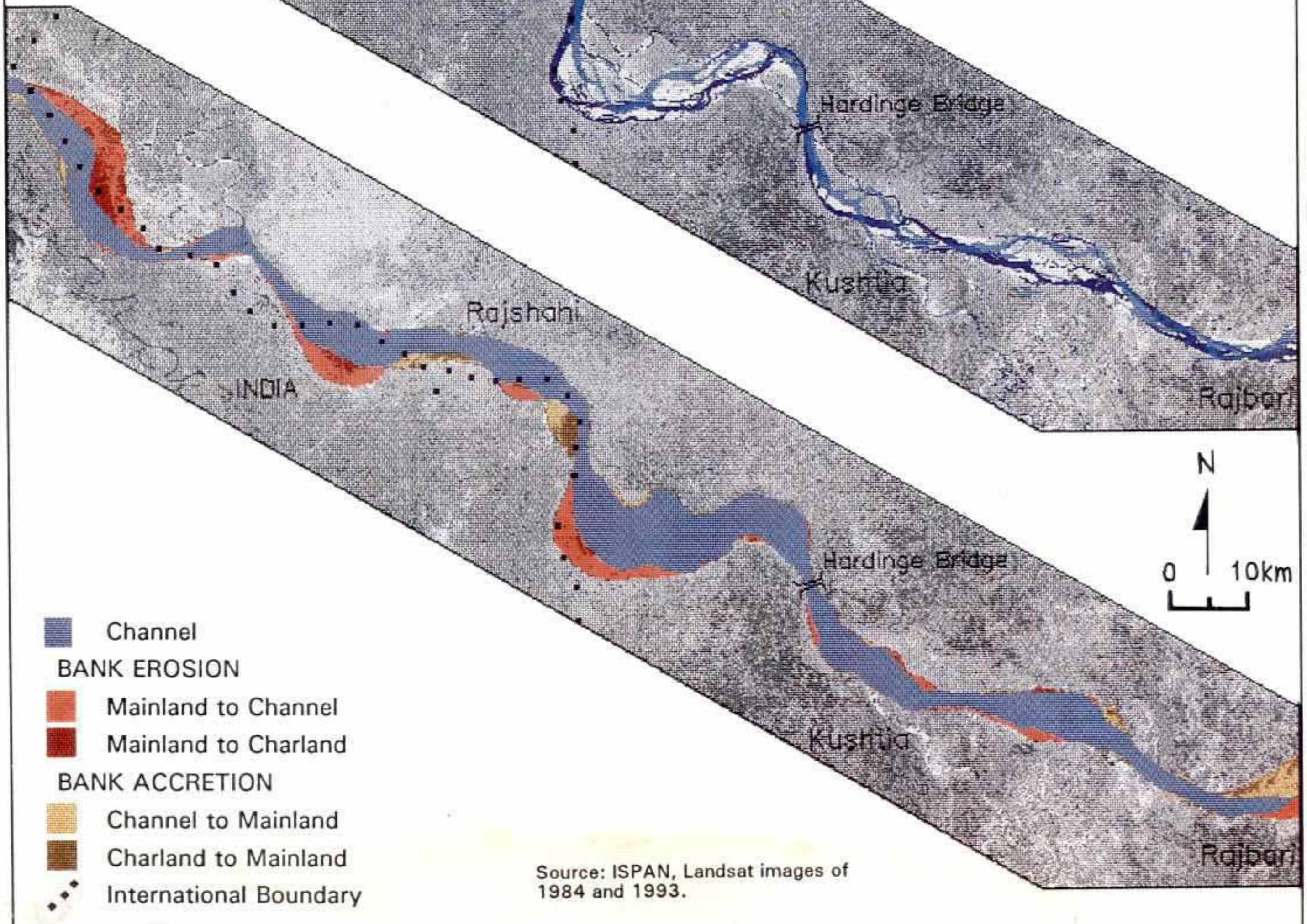


Figure 2.8 RIVER BANK EROSION AND ACCRETION 1984-93

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 done for the Ganges, and such analysis is needed to understand the complex changes that have occurred. 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 Ganges. Despite this, some general characterizations can be made.

The present planform of the Ganges main channel within the active geomorphological corridor displays elements of both braiding and meandering patterns. Large sweeping bends and shorter crossings characteristic of a meandering river can be identified, but chute and slough channels remain active annually during the summer high flows, so that reaches of divided flow persist up to dominant discharge, as found in a braided river.

Upstream of the Hardinge Bridge/Gorai off-take meandering tends to dominate the planform, and the overall pattern is that of a highly sinuous, multi-threaded channel. Downstream of this reach there is a marked change. In that area, braiding predominates, and the overall pattern is that of an almost straight, multi-threaded channel with meandering anabranches.

Dynamic adjustments of channel planform occur through a variety of evolutionary sequences. Channel bends tend to grow in amplitude and to migrate downstream, although bends may remain almost static for decades when they encounter erosion-resistant materials at the edge of the floodplain. Historically, chute cut-offs through the chars are common, but neck cut-offs through mainland areas are very rare. Over the longer term, periodic bend loop development and chute cut-off of the bend at Sara radically alters the approach flow orientation at Hardinge Bridge, which in turn has important effects at the Gorai off-take.

Growing island chars produce divided flow in major anabranches that drives active bank erosion at the outer margins of the channel. Eventually, flow bisects the char, tending to abandon one or both of the outer anabranches. This has been observed in satellite image sequences near the Gorai off-take. Individual anabranches themselves are large rivers and display either meandering or braiding tendencies, so it is not unusual to observe two (or more) scales of channel pattern in the same reach, involving the larger primary braided channel and smaller anabranches.

2.5.2 Image Analysis of Within-Bank Changes

Changes in within-bank land cover between 1984 and 1993 are very complex. The within-bank area on each of the images was digitally classified as explained in Section 2.3.3. Char[2] 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 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 using the classified images and image-derived banklines.

Table 2.6 Trends in Within-Bank Area 1984-1993

Area	1984	1993	1993 as % of 1984
Total (ha)	89,198	100,204	112
Water (ha)	28,618	28,982	101
Sand (ha)	36,225	35,663	98
Char (ha)	24,355	35,558	146
% Water/Sand	73	65	—
% Char	27	35	—

Source: FAP 19 satellite image analysis

Tables 2.6 and 2.7 summarize this data and indicates that as the river has widened in the upper and middle reaches, island chars have increased notably in total area, particularly in the upper reach and to a lesser degree in the lower reach. This accretion of within-bank charland is much higher than in the Meghna or Padma study areas.

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

Reach	1984	1993	1993 as % of 1984
Upper			
Total (ha)	35,924	43,875	122
Water (ha)	12,020	13,255	110
Sand (ha)	15,135	14,432	95
Char (ha)	8,769	16,188	185
% Char	24	37	—
Middle			
Total (ha)	25,812	29,729	115
Water (ha)	7,167	7030	98
Sand (ha)	8,836	11,181	127
Char (ha)	9,810	11,518	117
% Char	38	38	—
Lower			
Total (ha)	27,462	26,600	97
Water (ha)	9,432	8,698	92
Sand (ha)	12,255	10,050	82
Char (ha)	5,775	7,852	136
% Char	21	30	—

Source: FAP 19 satellite image analysis

In 1993, there was almost 1.5 times more vegetated charland within the banklines than there was in 1984. As the river widened, the area of water remained nearly the same in all reaches. Although the sand area did not change across the entire river, there were offsetting changes in the middle and lower reaches. The middle reach gained 2,345 ha (27 percent) of sand, while the lower reach lost 2,205 ha (18 percent). Char area, on the other hand, showed major increases of 7,419 ha (85 percent) in the upper reach and 2,077 ha (36 percent) in the lower reach.

The amount of water flowing in the Ganges at Hardinge Bridge fell markedly between the times the two images were taken (in March 1984 the flow was 1,304 cumecs, 2.5 times greater than the average for 1989-92; FAP 4, 1993). The changes in within-bank areas therefore may reflect these changes in flow. For example, sand deposition may be affected, and if the dry season channels contract, more vegetation may appear.

Widening was associated with a major increase in char area in the upper reach chars. Within-bank area in the lower reach actually decreased, while the char area increased. This indicates that accreting charland was displacing water/sand. Overall, the increase in charland between 1984 and 1993 neatly compensates for the concurrent loss of mainland. Table 2.6 shows there has been a net loss of floodplain mainland of some 11,006 ha in the whole study area, and a gain of about 11,203 ha of vegetated charland within the banklines. Broken down by reach, this same relationship between char formation and eroded mainland exists in the upper reach. In the middle and lower reaches offsetting relationships are more complex. Chapter 3 shows that the quality and carrying capacity of this new land is very different from that of the mainland lost.

Figure 2.9 illustrates these 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 pockets classified as sand mixed with classified charland. 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 significantly in area as detailed above, only in the middle reach is there much vegetated charland common to the two images. The majority of char inhabitants will therefore have been forced to move as the char system changed.

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 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 outside the present channel in the upper reach, along the south bank of the middle reach, and both banks of the lower reach is confirmed. It is also apparent that some chars in the middle reach have been above water for as much as 30 years.

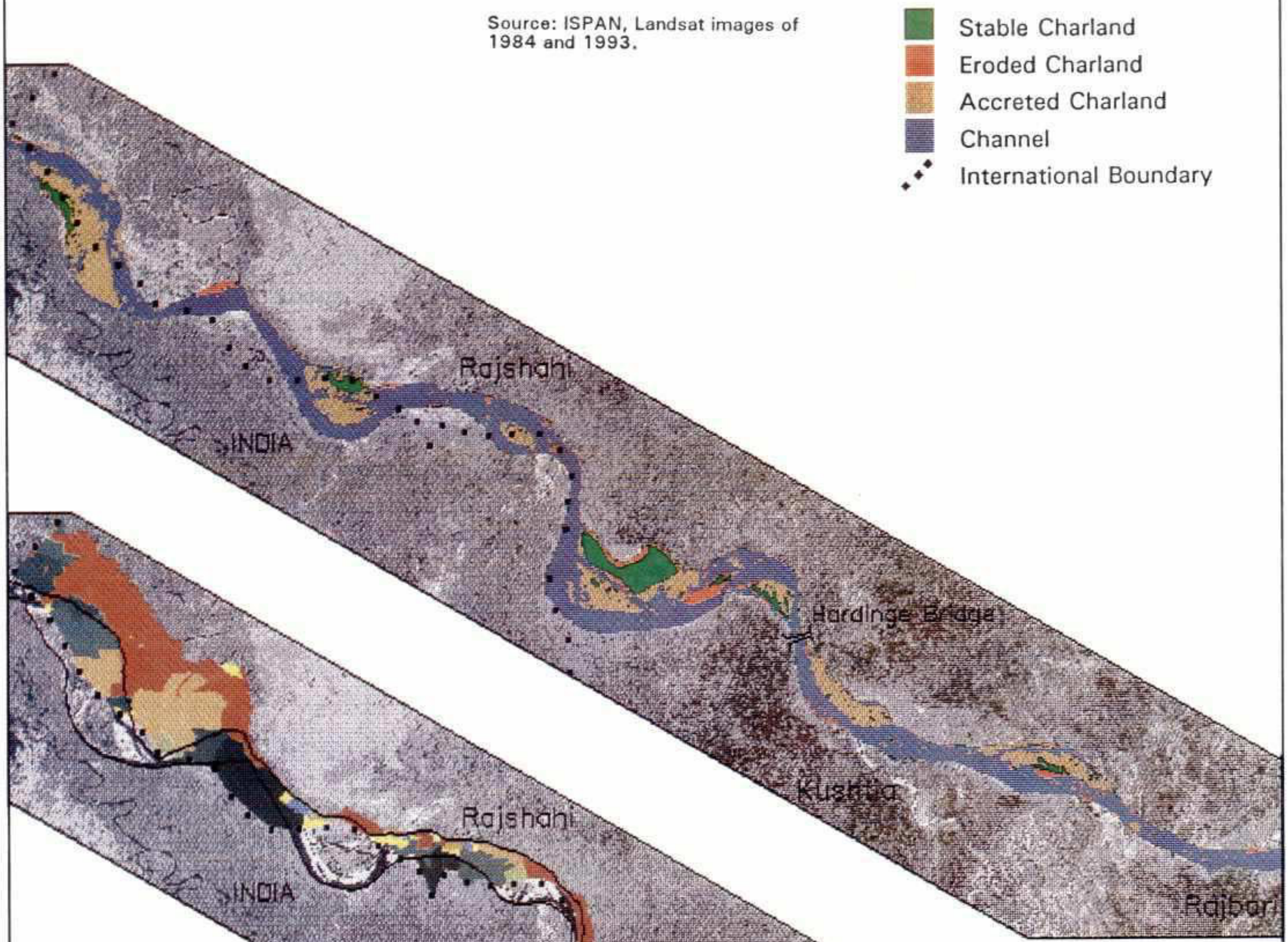
If it is assumed that past persistence implies that chars will continue unbroken existence here, then interventions such as flood shelters and more permanent settlements might be viable.

2.6 Future Implications

Interpreting and predicting the complexities of these in-bank channel forms and changes is practically impossible, but there is an apparent cyclical tendency whereby meandering and braiding trends alternate over perhaps a 100- to 200-year time span. Within this period, the channel swings across the active corridor either due to meander progression or the growth and destruction of island chars with a periodicity of about 50 years. In either case, most changes occur within the active corridor and attack of the floodplain outside the active corridor is limited. For example, examination of the recent planform shifting along the middle and lower reaches indicates that actual attack of the floodplain occurs along only about 15 percent of the water course. This includes locations where the channel is locked against resistant outcrops of clay in the outer bank in large loops upstream of Hardinge Bridge.

The implications are that chars in the active corridor are much more liable to be attacked and destroyed than "intact" floodplain, including that situated just behind the edge of the active corridor. Improvements to charland infrastructure would seem unwise on this basis, unless coupled with a program of channel stabilization. While 80 years'

Figure 2.9 CHARLAND EROSION AND ACCRETION 1984-1993



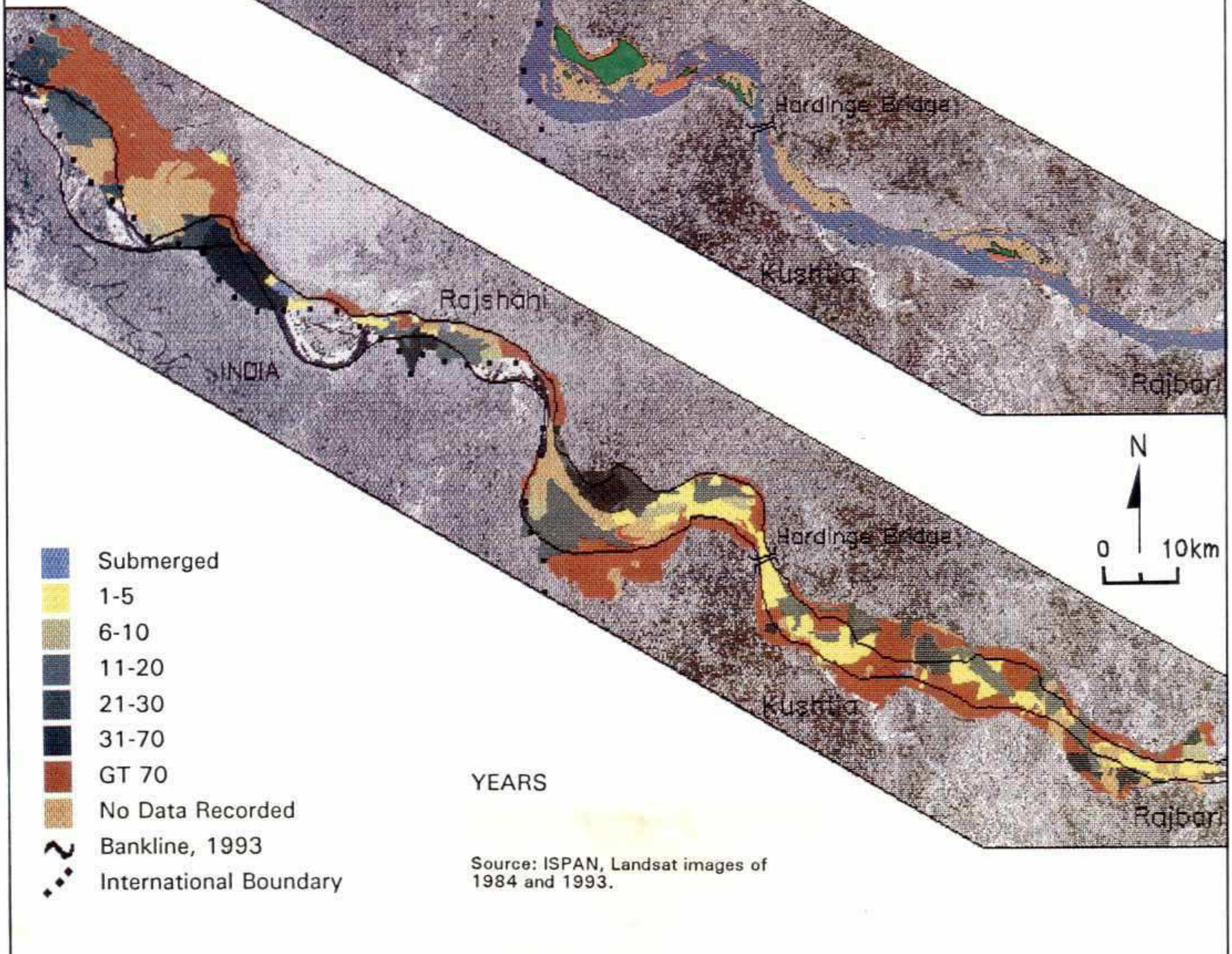


Figure 2.10 AGE OF LAND

experience of training works around the Hardinge Bridge show this can be done, it would require a massive and sustained investment to expand this type of measure. Instead, viable benefits to char people, in terms of more permanent land, might be achieved by minimizing the use of hard structures and relying heavily on active floodplain management using local materials.

FAP 4 (1993) has also argued the need for river training works to keep the Gorai off-take open. If the Gorai were to become only a high flow overspill channel like the Chandina, the environmental impact for the southwest region, including polders, the Khulna Basin, the Port of Mongla, and the Sundarbans mangrove forest, are predicted to be potentially catastrophic (FAP 4, 1993). Any measures to counteract this problem will depend on a better understanding of the planform vagaries of the Ganges main channel within its active corridor, and trials of active floodplain management.

Any interventions should also take account of and help the substantial number of people who live on the flood- and erosion-prone chars of the Ganges. 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. 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.

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). A few of the uninhabited mauzas are submerged throughout the year, and the majority in the Ganges charlands have only sand and natural vegetation above water during the dry season and are generally submerged in the monsoon. Some uninhabited mauzas in the chars are cultivated in the dry season by temporary settlers and then abandoned in the monsoon when they are submerged. Status was verified by superimposing mauza boundaries on the land use classification map derived from satellite imagery. The survey interviews were conducted in June and July 1993, about four months after the satellite image was taken, some of the temporary settlements on newly accreted chars may have been abandoned by the time of the Inventory Survey.

Data for some questions are missing from the survey because respondents in the mauza were unsure of information. In addition, several of the places for which data were collected and which are mapped in this chapter are not true mauzas, but areas of accreted public land (*khas* land) that have been settled but do not form a revenue village. To make the inventory as comprehensive as possible these areas, mainly concentrated in the middle and lower reaches, were surveyed where possible. Only two such areas were omitted in collecting inventory data. A few mauzas along the embankments bounding the study area were reported to be wholly protected by the inventory teams, but small corners are shown within the study area by the GIS. These areas are likely to be farmland with villages behind the embankment, but they have been treated as having missing data. One mauza in the lower reach was not surveyed because the Small Area Atlas shows two mauzas with the same geocode in Pabna Thana. In all cases, mauzas with missing data have been colored pale green on the maps, except in the flood-related maps, where mauzas with missing data are colored sandy-fawn. Areas of *khas* land and newly created mauzas were not included in the 1981 census and are shown as having missing population data in that year.

The *pourashava* of Nawabganj, although adjoining the study area, was excluded from survey because the inventory was not designed for urban areas. Rajshahi and Pabna urban areas also border the study area but are protected by embankments.

Most of the river's left (north) bank and most of its right (south) bank in the middle and lower reaches are embanked. In the study area, 226 (31 percent) mauzas are split by these embankments. 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 information than collecting data for whole mauzas from officials. The 1991 census data, therefore, are 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), are summarized in Appendix B. The "unprotected mainland" category in the appendix tables includes both setback land and open floodplain adjoining the river where there are neither existing nor proposed embankments.

The tables, which cover the same attributes as 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 about 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 Ganges Charland Study area constitutes 156,800 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 = 156,800 ha)

Category	Area (ha)	Percent
Submerged	785	1
Island Char	46,837	30
Attached Char	45,578	29
Unprotected Mainland	63,600	40
Upper Reach	60,926	39
Middle Reach	41,242	26
Lower Reach	54,632	35

Source: Table B.1

The gross areas in Table 3.1 include areas that were underwater in the 1993 dry season. There are only 11 completely submerged mauzas, but extensive areas of water are included in the island char category, which raises the proportion of the study area listed as island char. The gross areas for mauzas were obtained from the digitized Police Station maps (Figure 1.3). The upper reach is the largest, and is distinguished by a relatively narrow main channel with extensive areas of attached charland and unprotected mainland on the upstream part of the north (left) bank. The southern boundary of this reach is the international border and in some places the present river channel is outside the study area.

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-four percent of digitized mauza areas were within ±10 percent of the BBS area, but 30 percent were more than 10 percent larger, suggesting that the atlas may have excluded water from the land area. The GIS estimates could be used to revise the official areas of mauzas.

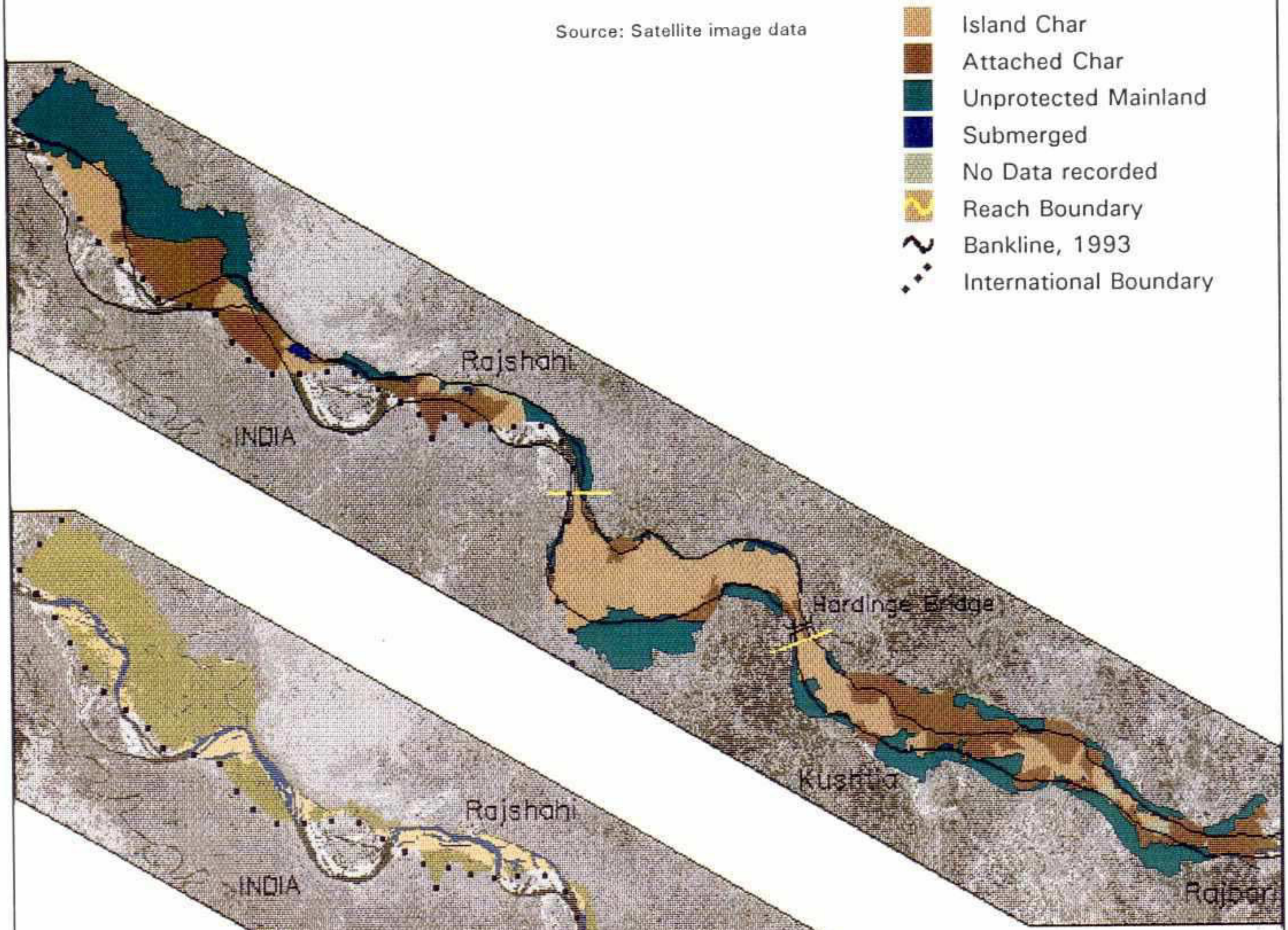
The digital land type classification, derived from the 1993 Landsat imagery and shown in Figure 3.2, was correlated with the mauza data and digitized mauza map. The three land categories used were: water, sand, and cultivated or vegetated, which included land recently cultivated or vegetated. The percentages 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.

Table 3.2 Study Area Land Type (percent)

GIS Interpretation of Surface Type	Land Categorization: Island Char*	Attached Char	Unprotected Mainland	All Areas
Water	22	15	9	15
Sand	37	19	7	20
Cultivated/Vegetated	41	66	84	65

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

Figure 3.1 CHARLAND CLASSIFICATION



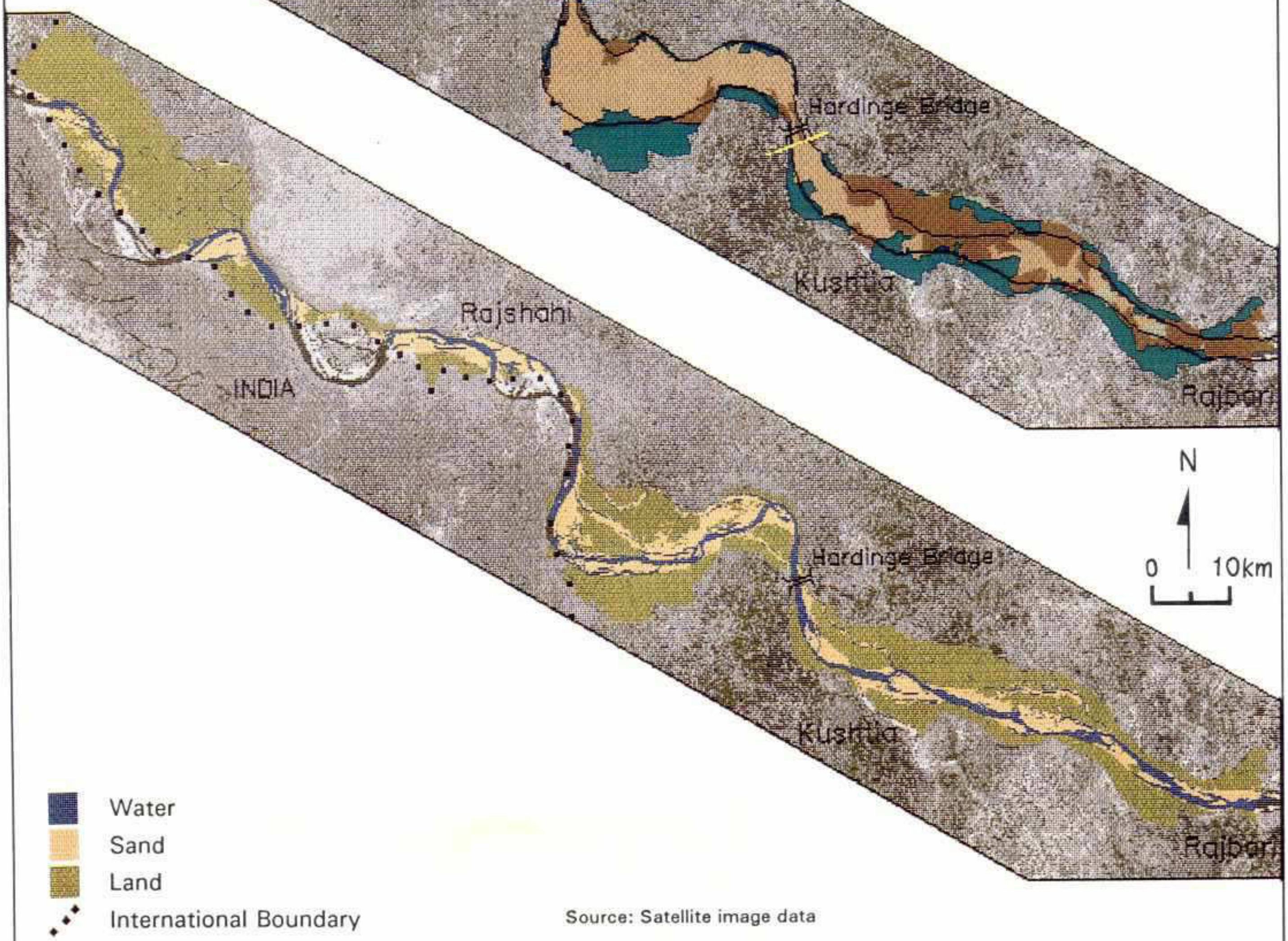


Figure 3.2 LAND COVER CLASSIFICATION 11 MARCH 1993

Only 15 percent of the Ganges study area was water in March 1993 (dry season). This reflects the low dry season flows common today in the Ganges. Tables B.2, B.3, and B.4 are breakdowns of water, sand, and vegetated areas, respectively. Twenty percent of the study area is sand in the dry season satellite image (58 percent of it in island chars). There is relatively more sand visible in the Ganges image than in the other main rivers, and most of it is in the middle reach (27 percent sand). Island char mauzas comprise large areas of bare sand in the Ganges, and have much less cultivated or vegetated land in the dry season than other land types (Table 3.2). These chars are inundated in the monsoon, when they form part of the normal monsoon river channel. Sand has limited economic value (although some is extracted for construction), so the attached chars and particularly the island chars, have lower productivity per ha of land.

The RRA in the Ganges, however, found that catkin grass is an important natural resource that is used by the char people 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-lower reach are covered in catkin grass, but some areas classified as sand grow catkin grass. 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 0.65 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 639 mauzas (including unofficial ones), the number of uninhabited mauzas (blue) increased from 187 in 1981 to 217 in 1993.

In 1981, the population was distributed between reaches in approximate proportion with their areas. Figure 3.3 shows that the narrow bands of setback land on the north bank and on the lower reach of the south bank had the highest population densities in 1981. There was an abrupt change in population density from low in the island and attached chars to high in unprotected mainland. The upper reach had higher population because it has few uninhabited mauzas and large areas of unprotected mainland.

Table 3.3 Study Area Population in 1981 and 1993

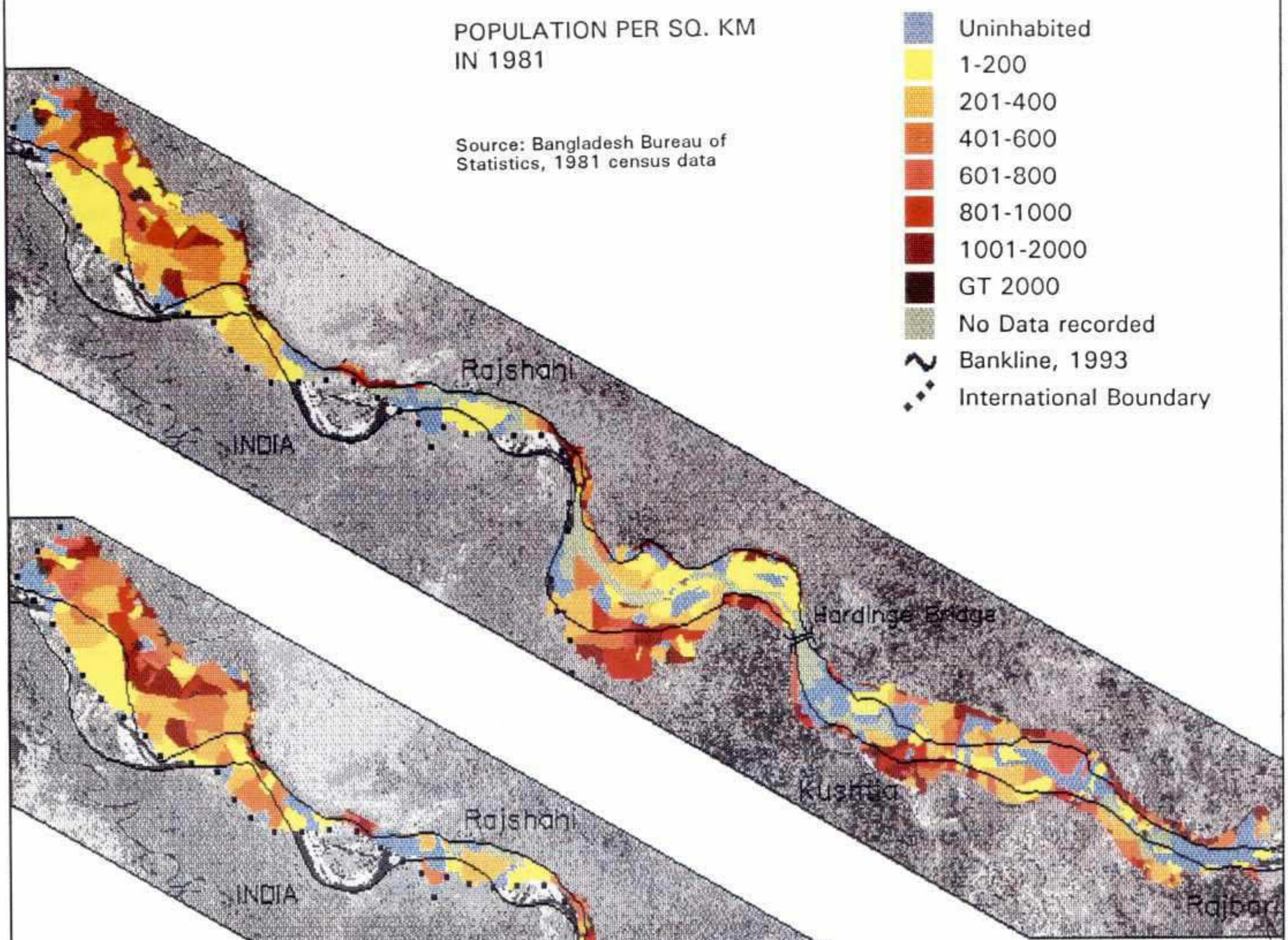
	1981		1993	
	Population	Percent	Population	Percent
Category	Total = 653,651		Total = 691,428	
Island Char*	68,552	11	54,395	8
Attached Char	119,983	18	141,245	20
Unprotected Mainland	465,116	71	495,788	72
Upper Reach	277,293	42	312,884	45
Middle Reach	157,167	24	119,251	17
Lower Reach	219,191	34	259,293	38

Source: Tables B.6, B.7; BBS Small Area Atlases and FAP 19 Field Survey
*Includes areas populated in 1993 but not covered in the 1981 census.

The population density in 1981 was 416 people per km^2 (including sand and water; Table 3.4), about 31 percent lower than the Bangladesh average of 605 people per km^2. Some presently inhabited *khas* land was not included in the 1981 census; these "mauzas" are shown as having no data recorded in Figure 3.3 but are presumed to have been uninhabited in the population density estimates.

Figure 3.3 clearly shows that uninhabited mauzas (pale blue) were concentrated in a line along

Figure 3.3 1981 POPULATION DENSITY BY MAUZA



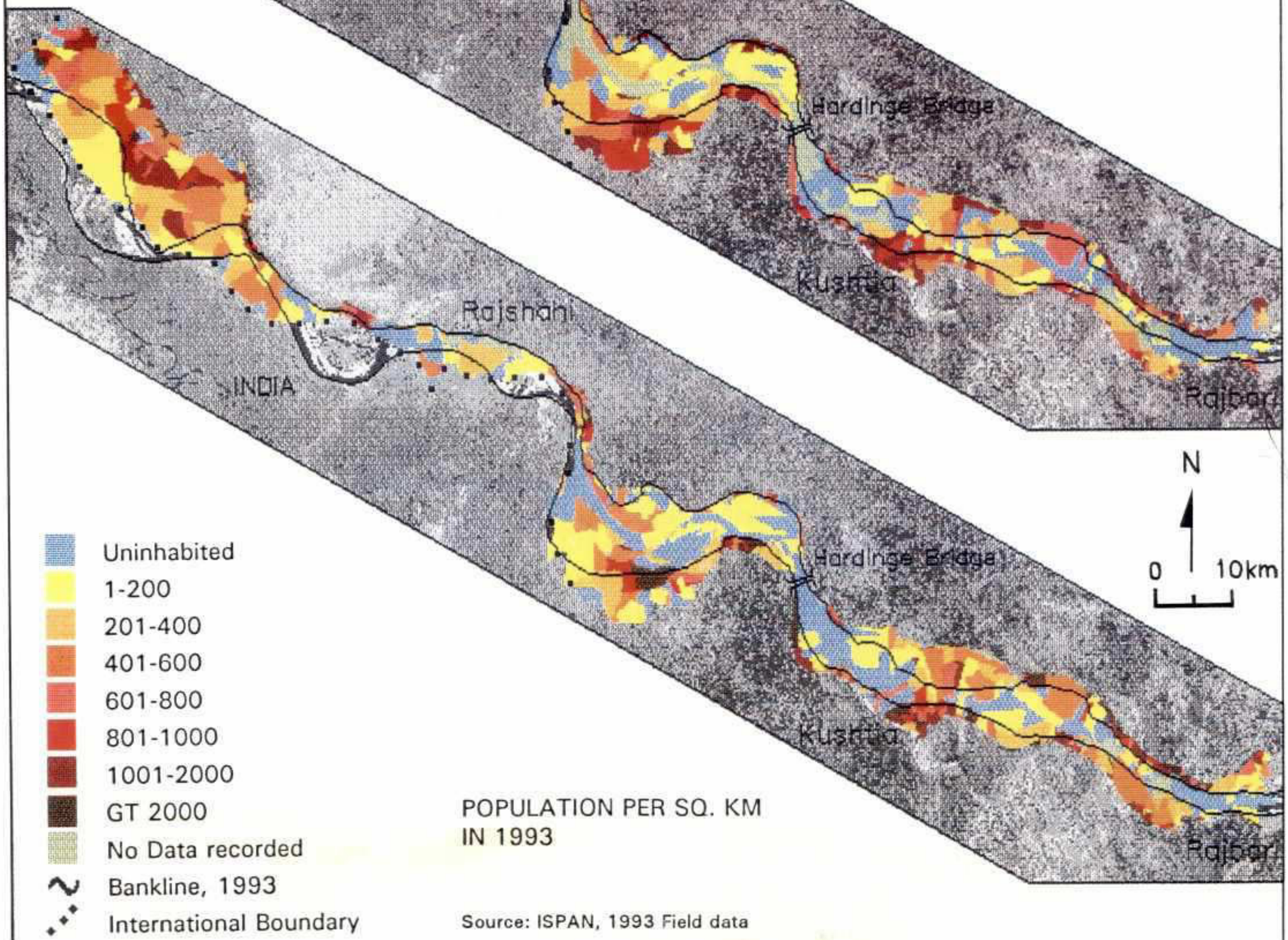


Figure 3.4 1993 POPULATION DENSITY BY MAUZA

the Ganges. Low population densities (1 to 200 people per km²; yellow in the figure) in 1981 were concentrated in the island chars, particularly in the middle and upper reaches. In addition, the attached chars had relatively low populations (orange).

The study area population, based on the 1993 inventory,[1] is estimated to be 691,428. 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 attached chars and unprotected mainland of the upper and lower reaches, with notable concentrations in the lower reach near the Gorai (Kushtia) on the south bank and farther downstream on the north bank setback land (brown in Figure 3.4).

The 1993 population density in the study area was only 58 percent of the Bangladesh average of 763 people per km², and was lower than in the other main river charlands. Only in the unprotected mainland was the population density (779 people per km²) comparable to the national average. This results from its having more mauzas with high population densities (brown and dark red in Figure 3.4). Mainland population density is low compared with charlands in the other main rivers mainly because the setback land forms a very narrow band, and few people live on the riverside in the many mauzas that are bisected by the embankment. In addition, the unprotected mainland of Nawabganj (upper reach) is less densely populated than might be expected, and population densities are also exceptionally low in the middle reach. Excluding the few submerged mauzas (Table B.8) leaves population density virtually unchanged.

Very low population densities (fewer than 200 people per km²; yellow in the figure) are concentrated along both sides of the uninhabited main river channel and are mainly within the banklines in the island chars (which average only 116 people per km², excluding submerged mauzas). Most island char mauzas in the lower reach were uninhabited. Average densities in the attached chars range from 200 to 600 people per km² (orange). Variation in population density is apparently linked with land productivity, recent erosion experience, and flood risks. Comparison of Figures 3.3 and 3.4 shows some expansion of the uninhabited area in the middle reach, and low populations where there bank erosion has occurred in the upper and middle reaches.

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 population increased 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 growth in the study area has been well below the national average, it has experienced a complex pattern of declines and increases, some of which may be related to the morphological changes shown in Chapter 2.

In Figure 3.5, yellow represents no change in

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	144	114	-21
Attached Char	263	310	+18
Unprotected Mainland	731	779	+7
Upper Reach	455	513	+12
Middle Reach	380	289	-24
Lower Reach	401	474	+18
Study Area Average	416	440	+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 Ganges charland study area. Areas are whole mauzas including water and submerged mauzas, which accounts for the low population densities.

Figure 3.5 CHANGE IN POPULATION DENSITY 1981-1993

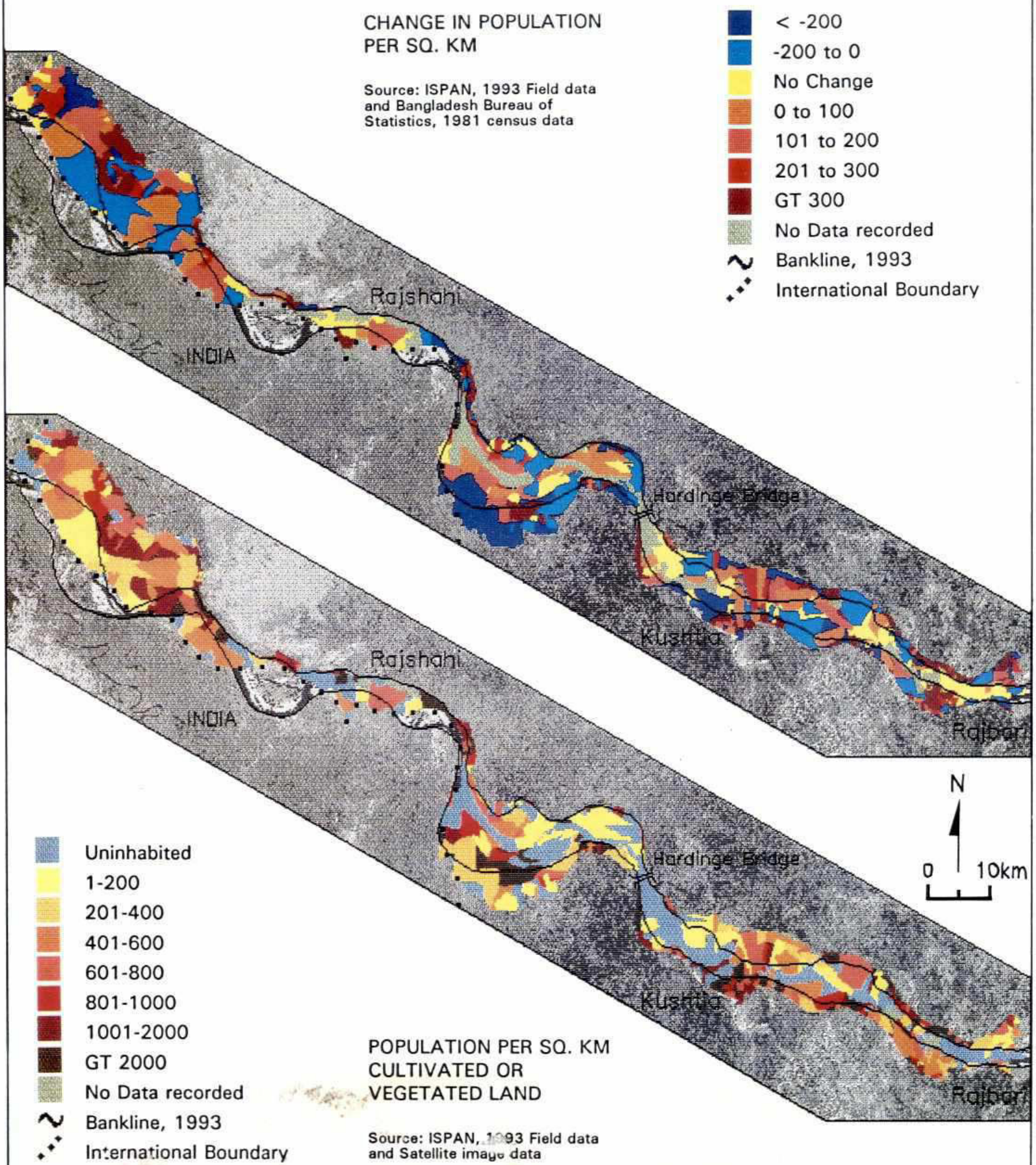


Figure 3.6 HUMAN POPULATION TO VEGETATED LAND 1993

population and therefore highlights the mauzas that remained uninhabited between 1981 and 1993. These are concentrated in the relatively stable single channel, opposite Rajshahi and in the lower reach, for example. Figure 3.5 shows that many mauzas experienced a population decline since 1981 (blue). These fall into four main groups:

- mauzas in the mainland and chars of Nawabganj and Shibganj (northeast upper reach), where bank erosion has occurred and where people who were isolated on the south bank of the river between the Ganges and Indian border may have left for economic reasons;
- south bank unprotected mainland and island chars in the middle reach, which have experienced rapid bank erosion and severe flooding (Section 3.6). Depopulation mainly occurred in mainland mauzas close to the Indian border. The reasons for this deserve further investigation;
- island and attached chars in the lower reach, which have been affected by shifts in river channels within the banklines and thus a changing configuration of chars; and
- setback mauzas along both edges of the study area. The inventory only surveyed the unprotected part of these mauzas, and the riverside portion probably had lower populations in 1981 than the average for all of these mauzas (which was mapped). These mauzas are unlikely to have experienced real depopulation, and the 1981 population estimates for them were probably too high.

Population declined throughout the river in the island chars, as well as locally in attached chars and unprotected mainland. Much of this was associated with morphological changes to island chars within the banklines, and with channel widening and consequent bank erosion. Other social and economic factors may also result in population shifts in the border areas.

Areas that gained the most population between 1981 and 1993 (red and dark red) are concentrated in attached chars and some unprotected mainland in the upper and lower reaches. These areas are mainly outside the banklines. There has also been local population growth within the banklines as island and attached chars emerged and stabilized. In the upper and middle reaches some compensating increases in population seem to have occurred in mauzas adjacent to ones where population declined. In the upper reach, this suggests that people have moved away from the chars, but in the middle reach it more likely represents a move into the chars from the mainland by the Indian border. Further study and comparison with 1991 census data are needed to understand the reasons for such changes. In the lower reach setback areas near Pabna there has been little bank erosion, and population increases closer to the national average occurred.

Population growth in the upper reach was half that of Bangladesh as a whole, yet its population density is the highest in the study area (Table 3.4). In the middle reach there has apparently been a major decline in population. Population density in the lower reach was only 66 percent of the national average in 1981, but it has grown almost at the national average rate. The low population growth reflects a combination of major loss of population from island chars, moderate growth in the attached chars, and apparently low growth in unprotected mainland (but this may reflect an uneven distribution of people within mauzas bisected by the embankments). Some of these trends appear closely related to erosion incidence (Chapter 2), but study of the wider context of change in this border region is needed. 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 complications introduced by the extent of dry season water area, which is higher for island chars (Table 3.2). Although land availability varies from season to season, monsoon season land areas are unknown. The rapid rural appraisal 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.

Table 3.5 Cultivable Land Per Capita 1991/93

Land Type	Hectares Per Person	People Per km²
Island Char	0.35	282
Attached Char	0.21	472
Unprotected Mainland	0.11	927
Study Area*	0.15	673
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, which did not include the Ganges, and may underestimate absentee land ownership.

The 1993 population relative to productive land is lowest (yellow and pale orange in Figure 3.6) in the main river channel (island and attached chars) in all reaches of the river (in these areas it is rarely above 400 people per km^2). Table 3.5 shows that there is much more usable land available per capita in the island chars, and rather more in the attached chars. Even in the unprotected mainland there is more cultivable land available per capita than in Bangladesh as a whole. Population per km^2 of vegetated land is highest in the unprotected mainland of the lower reach, where the river channel has been relatively stable in recent years. In that area, there are more than 1,000 people per km^2 of vegetated land. In this reach, the charlands form a narrow band between the embankments. There is a great difference here between the densely populated mainland fringe and the very low populations (186 people per km^2 of vegetated land) in the island chars. It is likely that people from mainland mauzas make use of these chars.

The low population density on vegetated charland compared to the Bangladesh average presumably reflects the very sandy soils, 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 include areas adjacent to urban centers (such as Rajshahi), and parts of the south bank of the middle reach, where people have apparently moved from the border area into accreting island chars. 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 123,447 households in the study area in 1993 (Table B.12). Mean household size is less than six people in all reaches and char types and averages 5.6 people (Table B.13). It is unclear why households are so small in the Ganges 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.

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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

Very little permanent out- or in-migration (Figures 3.7 and 3.8) was reported in the Ganges charlands in 1992. Either population shifts were not reported in the inventory or the changes in population distribution between 1981 and 1993 had all occurred before 1992. Out-migration was limited to a few mauzas along the banklines that were subject to bank erosion in 1992. In-migration was also generally low but was widespread between char types. It appears that in 1992 there was little out-migration, but a more general adjustment of people moving into the charlands following stabilization and settlement of accreted chars (there was little erosion reported in that and the previous year). The movements may well have been local—from adjacent mauzas or from nearby areas of protected land—as households moved to take up residence where their land had accreted. The data are consistent with evidence from the RRA in the middle-lower reach, which found that periodic movement away and then back into chars occurred in response to erosion and accretion, and that in recent years chars were being resettled.

Less than one percent (566 households) of the study area population permanently migrated out in 1992 (Tables B.14 and B.15). This movement was very localized (Figure 3.7) and appears to have been associated with bank erosion. Little erosion seems to have occurred between 1989 and 1992 (Section 4.3), however, and few mauzas were affected so badly that people left permanently. Nonetheless, it seems likely that out-migration was under-reported.

Study area mauzas reported 3.5 times more permanent in-migrations than out-migrations in 1992 (Table B.16). Less than 2 percent of households present in 1993 had moved into their mauzas in the previous year (Table B.17). Permanent migration, therefore, is estimated to have resulted in 1 percent more households in 1992. In-migration was generally concentrated in the island chars. It appears, therefore, that people are moving to take advantage of newly accreted chars as they re-emerge and stabilize (following char erosion reported for 1987-88 in the RRA but not in the inventory). They may also be moving into chars and unprotected mainland from areas where there has been bank erosion.

Permanent in-migration was concentrated in two areas. In the middle reach (Figure 3.8), particularly on the north bank and in island chars, 2.5 percent of households moved into their mauzas during 1992. On attached chars in the lower reach, 3 percent of households moved into their mauza in 1992. The RRA indicated that the 1992 pattern is not an isolated occurrence, and that char formations in the middle-lower reaches are constantly changing, forcing their inhabitants to move regularly either to and fro between char mauzas, or to and from mainland areas outside the study area.

Figure 3.7 PERMANENT OUT-MIGRATION

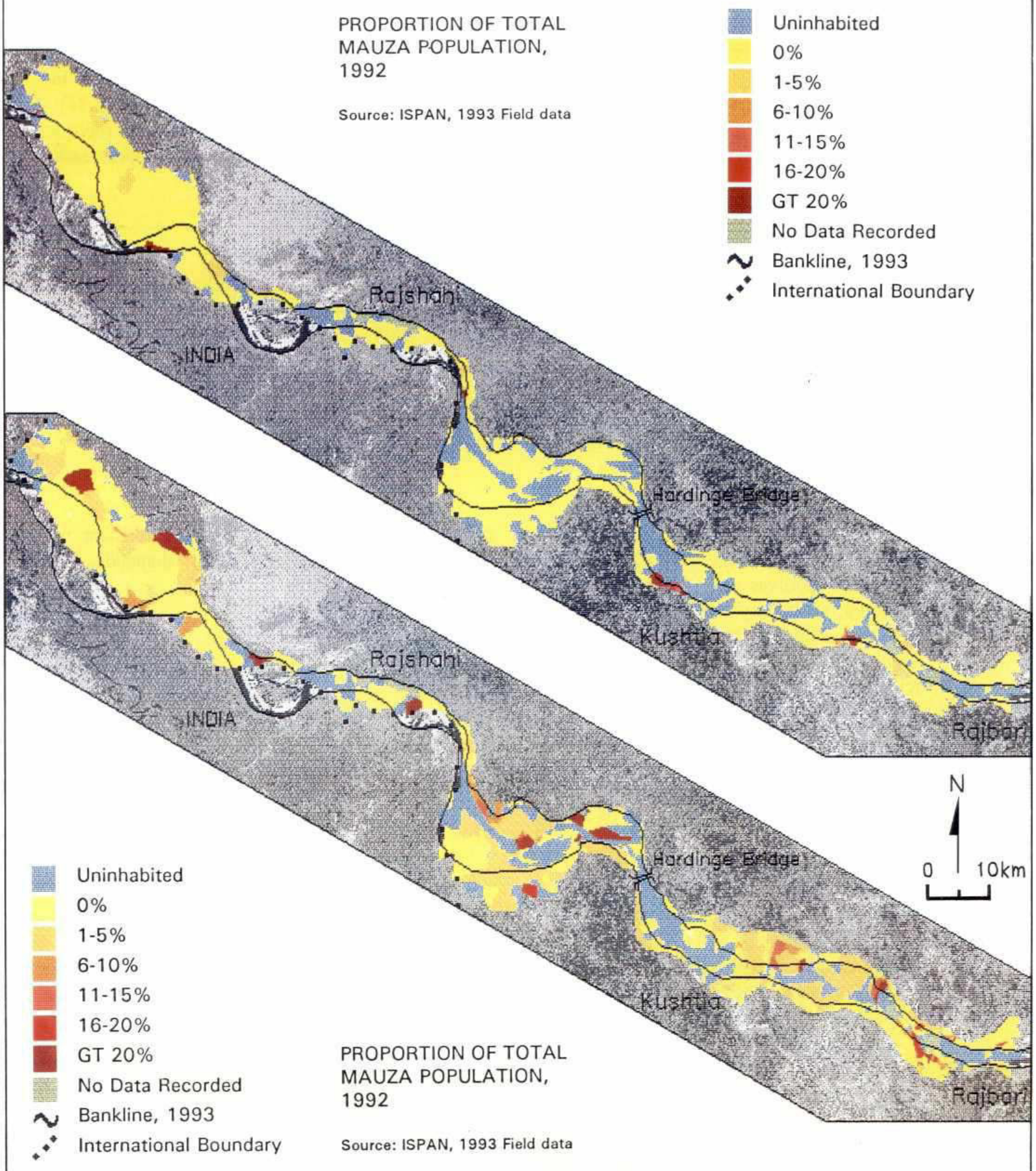


Figure 3.8 PERMANENT IN-MIGRATION

3.3.2 Seasonal Migration

Data were also collected on the total number of people seasonally out-migrating from their mauza of residence or seasonally in-migrating to a temporary abode. Only just over 1,800 people, about 0.2 percent of the 1993 population (Tables 3.6, B.18, and B.19), were reported to have temporarily migrated out of their mauzas. The RRA suggests that this is an underestimate. Seasonal migration often involves only some male household members, so if only one person per household migrated, it implies that in about 1.5 percent of households someone migrated out. This is a low incidence of out-migration compared with the Padma.

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	0.1	0.2	0.6	0.5
Permanent In-migration	2.8	2.0	1.4	1.6
Seasonal Out-migration	3.0	0.2	1.7	1.5
Seasonal In-migration	0.6	0.4	0.7	0.6

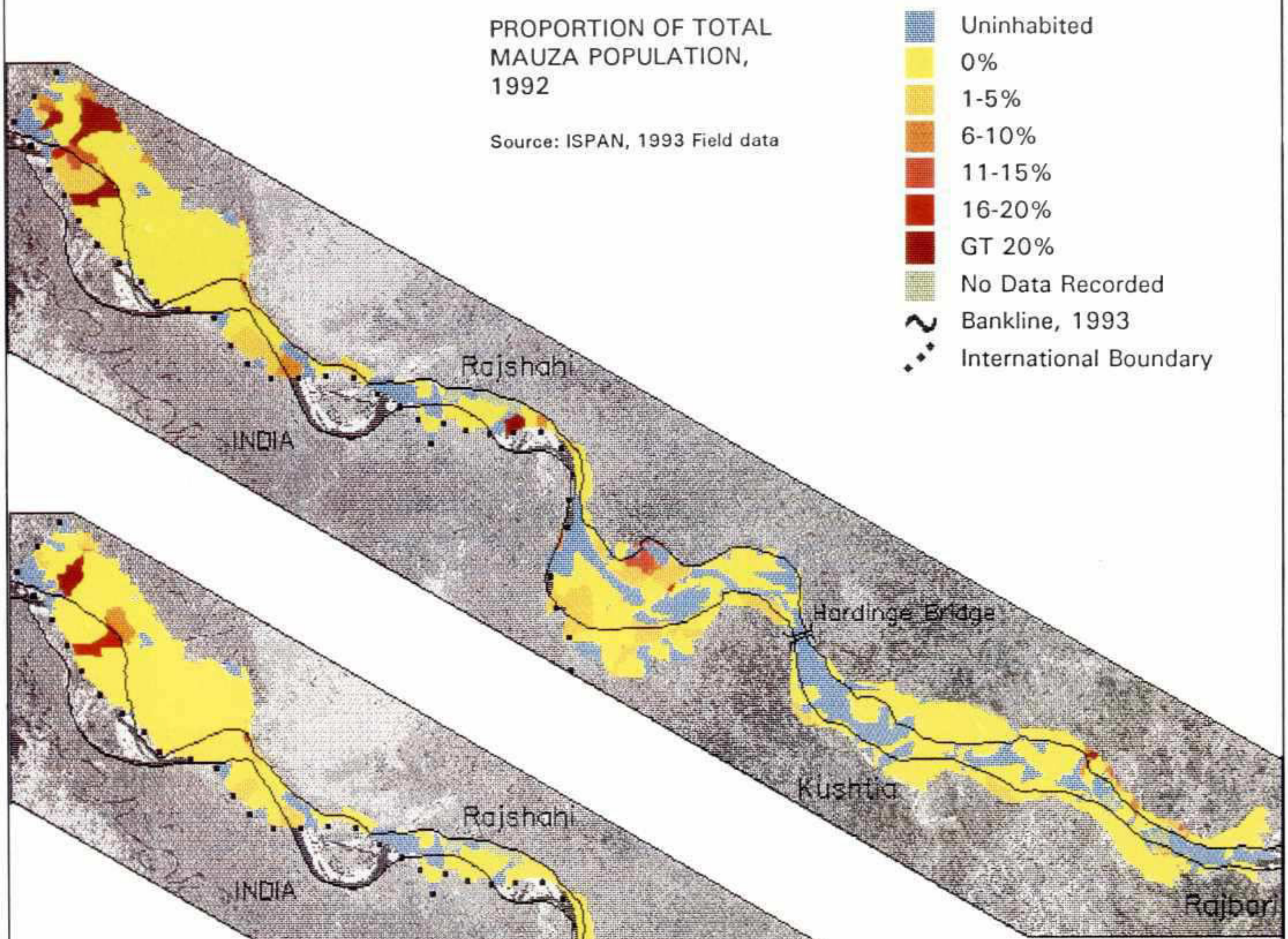
Source: Tables B.14 to B.21.
*Permanent migrants are households a percentage of all households; seasonal migrants are individuals expressed as a percentage of households.

Most mauzas did not report any seasonal out-migrants. Figure 3.9 indicates concentrations in three areas. Several factors appear to be behind this concentration:

- in the upper reach, in Shibganj Thana, there is a concentration of out-migration from mauzas near the Indian border that may consist of both local movements into adjacent mauzas (Figure 3.10) and movement across the border;
- in the middle reach there are movements out of char mauzas that are seasonally inundated, and between mauzas depending on the availability of cultivable land and agricultural work; and
- in the lower reach, in Sujanagar Thana, people may leave to find work in towns since communications are relatively good.

There were 60 percent fewer seasonal in-migrants than out-migrants reported in the study area in 1992 (Figure 3.10; Tables 3.6, B.20, and B.21). Seventy-three percent of in-migrants were reported from unprotected mainland in the upper reach (Shibganj). This likely was either movement to meet seasonal agricultural labor demands, or cross-border movement.

Figure 3.9 SEASONAL OUT-MIGRATION



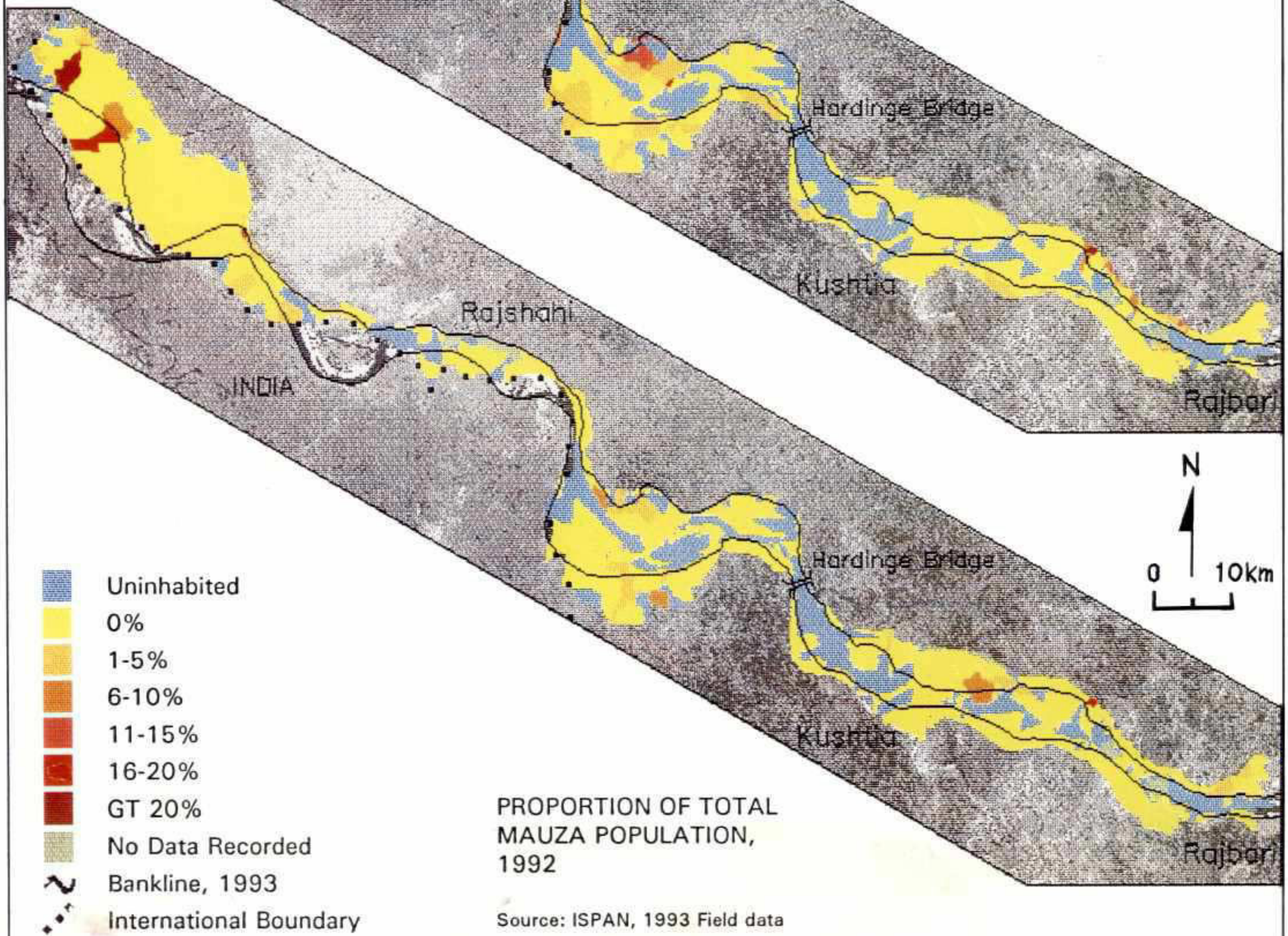


Figure 3.10 SEASONAL IN-MIGRATION

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, although most 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 charland access to high schools and health facilities.

3.4.1 Schools

A total of 224 mauzas (53 percent of inhabited mauzas) were reported to have primary schools (Tables 3.7 and B.22). Figure 3.11 shows that these schools are widely spread across the study area, and that most of the larger mauzas have them. Almost half of the inhabited mauzas have no primary school, however. The worst coverage is in the island and attached chars, where more than 50 percent of mauzas have no school (yellow), and in the middle and lower reaches. Given that many of these mauzas are small and in shifting sandy chars where population changes are common, the lack of schools is understandable. Some children from small mauzas may be able to attend schools in adjacent mauzas, but for many there appears to be no primary education opportunity in the area. The more extensive area of unprotected mainland in the upper reach is relatively stable and well served with primary schools.

There are, the survey found, many fewer secondary education opportunities (high schools) in the Ganges charlands. Figure 3.12 shows 73 high schools in the study area (Table B.23). Surprisingly, four high schools were reported in island char mauzas, but most of these mauzas include areas of mainland, which presumably is where these schools are located. There are less than 10,000 people per high school in all reaches. The fewest people per school is in the middle reach. Although many potential students in the chars appear to be separated from high schools by long distances, the narrowness of the Ganges charlands may put them reasonably close to high schools in the protected mainland areas. These are clearly more appropriate areas to build high schools as there is little erosion risk, but subsidized transport services are needed to enable char children to attend these schools.

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

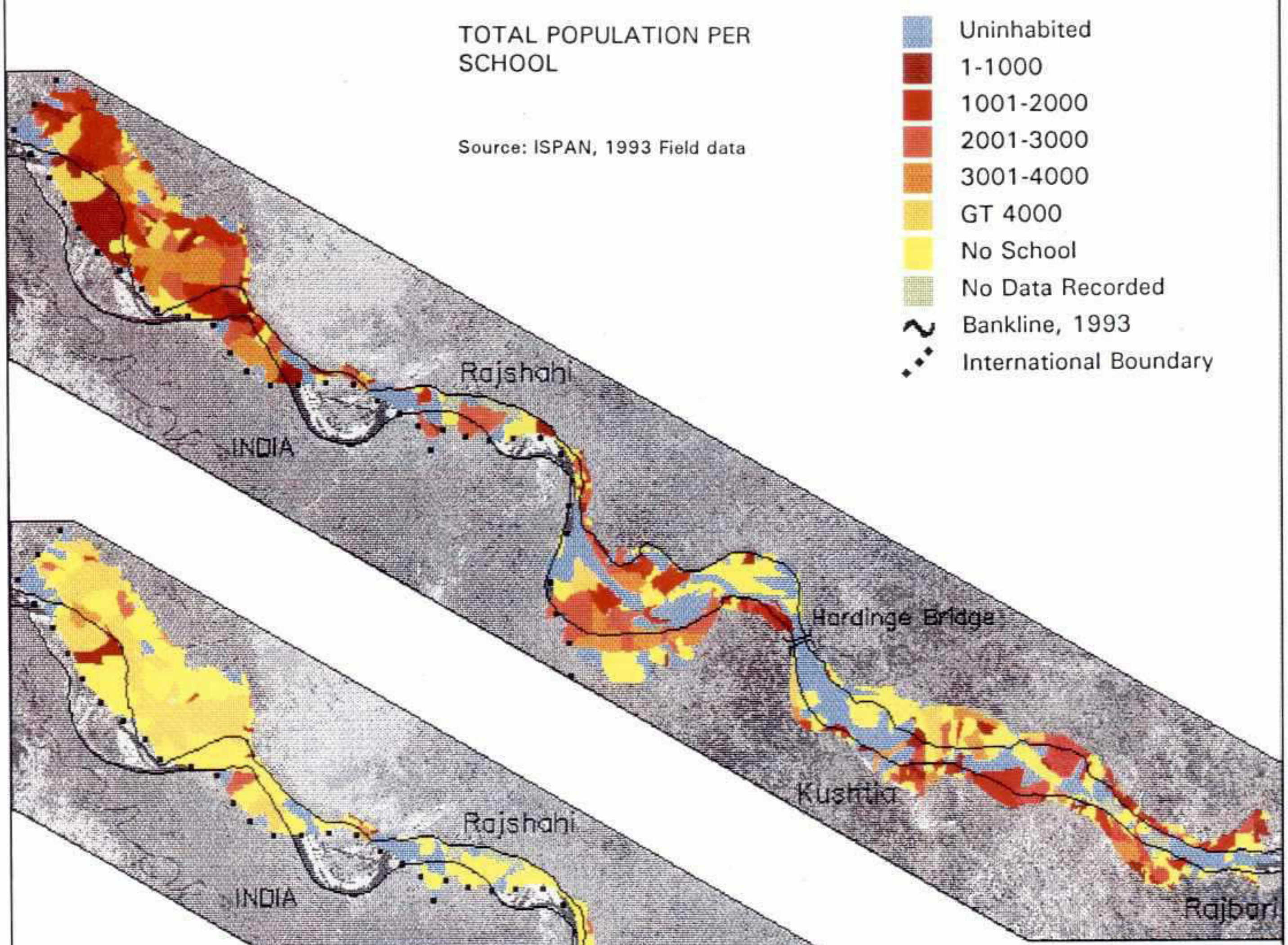
Table 3.7 Health and Education Services Provided to Inhabited Mauzas

Charland Type	Number of Mauzas	Inhabited Mauzas	Primary School (%)	High School (%)	Health Facility (%)
Island Char*	143	45	47	9	7
Attached Char	147	83	43	10	11
Unprotected Mainland	349	294	57	21	16
Total	639	422	53	17	14

Source: Tables B.22 to B.24.

*Includes 11 submerged mauzas.

Figure 3.11 PRIMARY SCHOOLS BY MAUZA



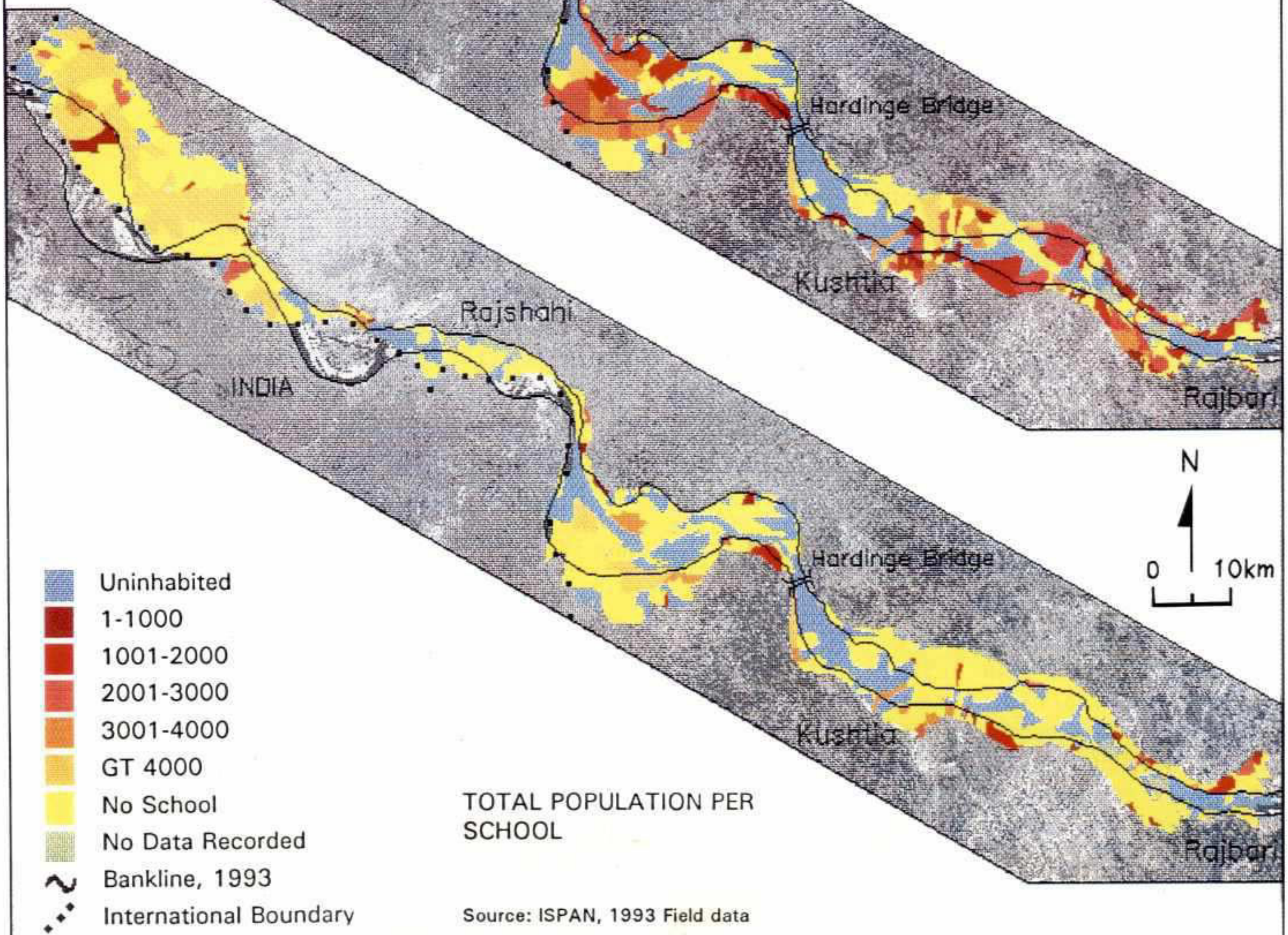


Figure 3.12 HIGH SCHOOLS BY MAUZA

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 112,700 children between five and nine years old and 92,600 in the 10-to-14 age range. For the study area this amounts to an average of 503 children per primary school (compared with 372 per primary school for all of Bangladesh) and 1,269 children per high school (compared with a Bangladesh average of 1,513). There is, therefore, a lack of primary school facilities in the Ganges charlands in comparison with the national average and with the Jamuna charlands. Although high school coverage is up to the national standard, the existence of a school does not necessarily ensure that education is either available or accessible.

3.4.2 Health Care

Figure 3.13 shows there are 59 mauzas (14 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.

While the survey found that health facility provision is relatively good, it is also biased toward the more stable unprotected mainland, where there are only about 10,500 people per facility compared with more than 18,000 per facility in the island chars (Tables 3.7 and B.24). The 11,700 people per health care center in the study area appears to be considerably better than the national average. In 1991, there were 2,819 government and non-government health care facilities (BBS, 1993), which is only about one facility for every 38,980 people. The difference in the Ganges charlands may be due to a higher level of NGO activity (see Section 3.4.4), and inclusion in the survey of facilities not included in the BBS data. Despite appearances, however, many people in island chars live up to 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). Coverage is good: of all inhabited mauzas, 83 percent were visited in the first half of 1993 prior to the field survey (red), and an additional 5 percent had been visited in 1992 (pink). Only 6 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.

3.4.3 Water Supply

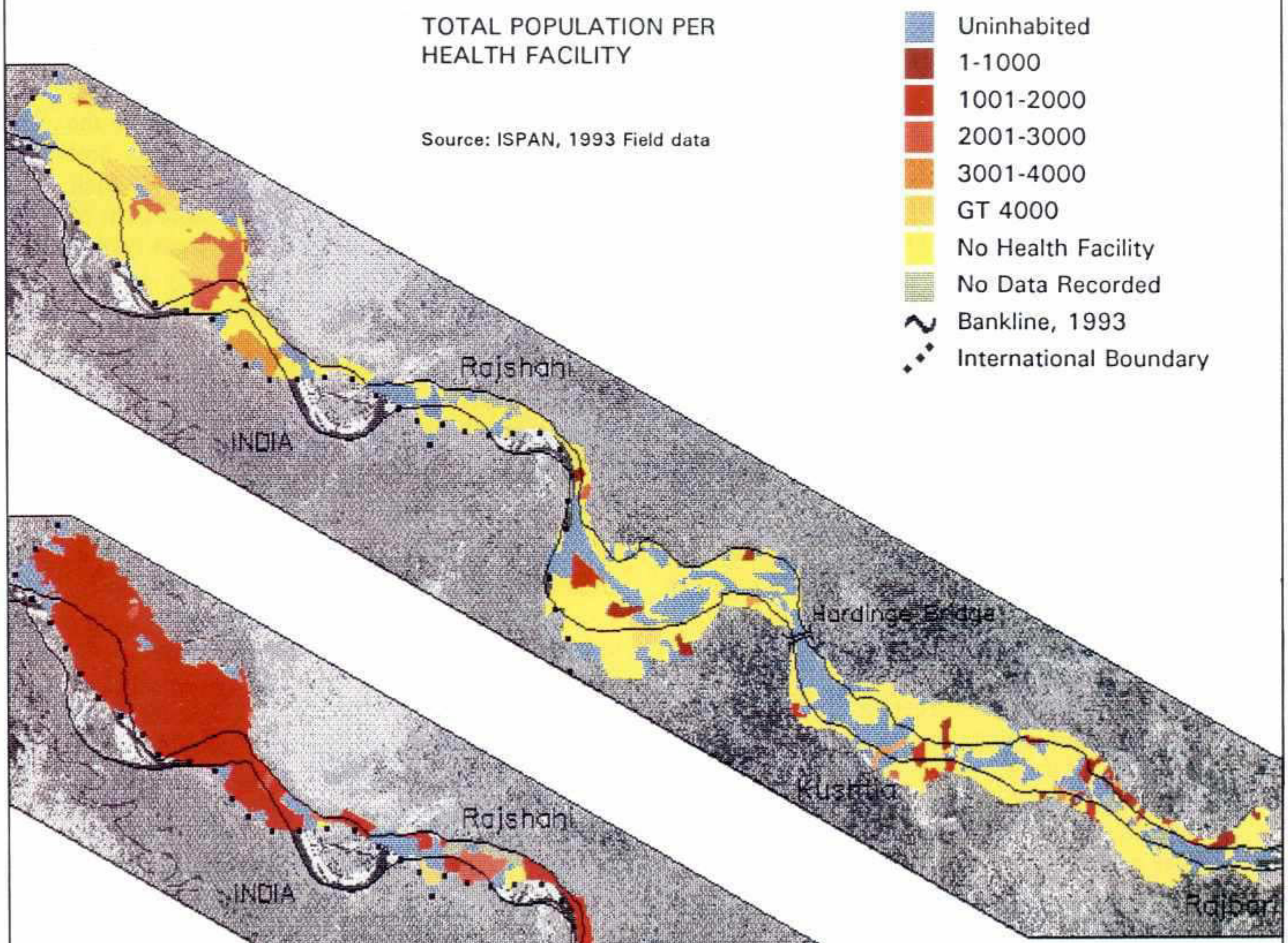
One fundamental means of preventing illness is to have a secure and pure source of drinking water. Under normal monsoon conditions, 99 percent of households in the study area reportedly use hand tubewells (HTW) for drinking water, the remainder drink river water. Table 3.8 shows that even in the island chars under normal conditions peoples' access to HTWs is good, and only 5 percent of households routinely drink river water.

Table 3.8 Drinking Water Source (percent of households)

	Normal Monsoon		1988 Flood	
Land Category	HTW	River	HTW	River
Island Char	95	5	26	74
Attached Char	99	1	63	37
Unprotected Mainland	99	1	67	33
All Areas*	99	1	63	37

Source: FAP 16/19 Field Survey
*Less than 0.1 percent of households used ponds or dug wells for water. Data for 1988 are only from those mauzas that were inhabited in both 1988 and 1993.

Figure 3.13 HEALTH FACILITIES BY MAUZA



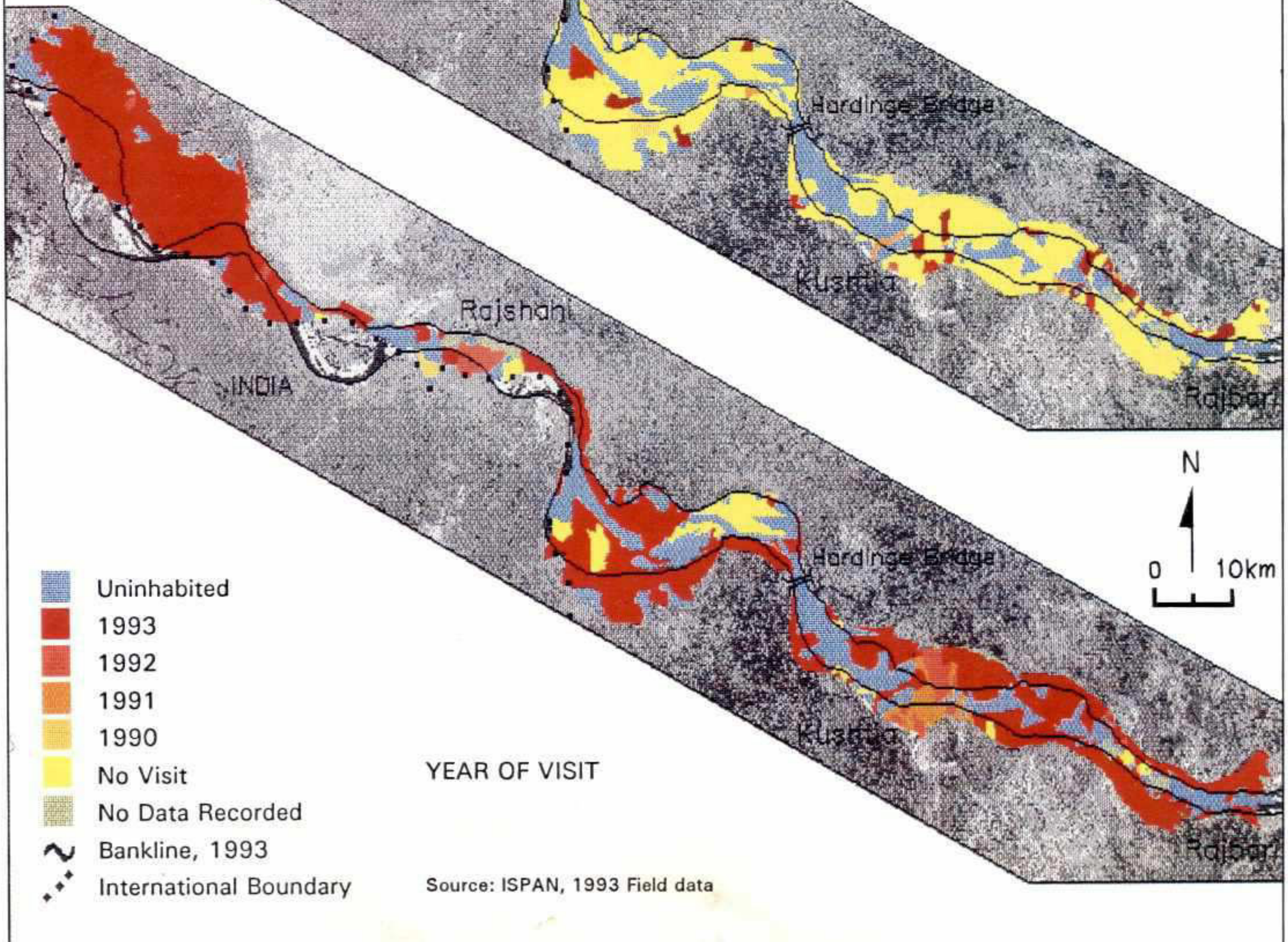


Figure 3.14 LAST VISIT BY HEALTH WORKER

Table 3.8 shows a complete reversal of drinking water sources during the 1988 flood: in island chars, 74 percent of households drank river or flood water. In the attached chars and unprotected mainland, where most households live, the impact on water supplies was much less severe, just over one third of households were forced to drink river/flood water, and the remainder still were able to continue using HTW water. Obviously, the health of island char people is likely to be adversely affected compared with the rest of the Ganges charlands in severe floods. Compared with other riverine chars the Ganges mainland people have relatively secure drinking water supplies.

3.4.4 Other Infrastructure

The distribution of markets in the study area was also investigated. There are a total of 93 mauzas (22 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 scarcer in the lower reach, where charland mauzas may be served by markets in nearby protected areas. Twenty-five mauzas had major markets. These are concentrated in unprotected mainland, but there are fewer in the upper reach. The lack of larger markets in the upper reach, which has only five, may not be a problem since the town of Nawabganj is on the fringe of this reach.

Rural electricity supplies are much better in the Ganges charlands than along the other main rivers. An average of 30 percent of inhabited mauzas have the service, and up to 39 percent of unprotected mainland mauzas have it. Only two island char mauzas have electricity, and they include areas 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 and targeting income-generating programs for char areas. Compared with the Jamuna and Meghna charlands, however, the charlands of the Ganges are already well covered by non-government development programs. Forty percent of inhabited mauzas presently are reported to be involved in NGO activities, although in some cases this may only indicate past relief activity. These programs are concentrated in the lower reach, where 56 percent of mauzas host NGO activities. NGOs tend to concentrate their activities in the most accessible and stable parts of the Ganges charlands—the mainland areas (where they cover 45 percent of mauzas)—only 18 percent of island char mauzas report having some NGO activity.

Access to the local power structure is important as a means of obtaining infrastructure and services, and in obtaining relief during floods. Only 7.3 percent of inhabited mauzas within the study area are reported to be home to the relevant union parishad chairman. Since there are an average of 13 mauzas per union in Bangladesh (BBS, 1993), an average of 7.7 percent of mauzas with chairmen resident is expected, and the Ganges charlands are average in this respect. On that basis, the island chars, of which only 2 percent have resident chairmen, are poorly represented in union parishads (although the distribution of ward members was not assessed). There was very good representation in the upper reach, where 14 percent of inhabited mauzas have a chairman present; this may be because these unions are smaller.

RESOURCE AVAILABILITY AND USE

3.5 Resource Availability and Use

3.5.1 Occupations and Overall Resource Base

This section documents a high dependence on cultivation in the Ganges chars involving a diverse range of crops, but with a particular emphasis on monsoon season paddy. Livestock also are a key part of this economy—a consequence of the charlands' abundant grazing—and there is relatively high cattle ownership in the area. The Ganges is the least important of the main rivers for commercial fishing, as national statistics (BBS, 1993) show, and the inventory found that fewer households earn a living from fishing than in the other charlands. Boat ownership is relatively low, but river transport is still an important resource for char people in the monsoon 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).

Thirty-eight percent of households reported that agriculture was their primary occupation (Table 3.9). Dependence on agriculture (cultivation of own land) was slightly higher on the attached chars in all three reaches, and was lowest (32 percent) in the middle reach island chars (Tables B.25 and B.26). In the island chars, day laboring and fishing are relatively important.

The occupational pattern is similar to that of the Jamuna charlands, with day laboring important in all areas. It is also more important than was found by FAP 14 in a wider range of flood environments. There is only moderate involvement in business (Tables 3.9 and B.30) in the study area considering the proximity of several large towns (Rajshahi, Pabna, and Nawabganj), all of which border the Ganges charlands.

Table 3.9 Main Occupations of Charland Households (percent)

Occupation	Island Char	Attached Char	Unprotected Mainland	Study Area	FAP 14 Average
Farming	36	46	43	43	38
Day Labor	44	35	41	40	30
Fishing	7	4	2	3	6
Business	6	12	9	9	8
Service	1	1	3	2	7
Other*	6	2	2	3	12
Total Households	9,816	25,148	87,619	122,583	7,723
Percent Fishing for Second Income	10	6	5	6	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. Fishing is the main occupation of only 3 percent of households, and another 6 percent fish as a secondary income source (Tables B.27, B.28, and B.29). Locally, fishing is more important. In the island chars, 7 percent of all households fish as a primary occupation and 10 percent do so as a secondary occupation. Fishing is also relatively important (9 percent or more of households fishing as a main occupation) in the small area of south bank attached chars (in the upper and lower reaches), and along the north bank of the middle reach.

The RRA in the middle-lower reach concentrated on island and attached chars and also found low dependence on fishing (10 percent of households reported fishing to earn income at some time during the year). The inventory data, then, reflect the lack of importance of the Ganges fishery, which is thought to have declined due to low dry season flows. The extensive embankments along the Ganges also limit floodplain availablity for fish. National statistics (BBS, 1993) show that in 1988-89 the Ganges contributed less than 1 percent of the total main river catch (including the Lower Meghna) and 4 percent of the total main river catch (excluding the Lower Meghna).

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 inventory questionnaire tried to improve respondent's accuracy in estimating cultivated area by calculating land area separately, and having them estimate the 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 respondent's estimates are 2 percent lower than the image estimate of vegetated area. Even so, there was considerable variation between the two estimates.

Respondents in the island chars reported 20 percent more cultivated land than image analysis indicates. There are two likely reasons: first, since catkin grass is commercially harvested, the respondents and survey teams may have counted grassland areas as cultivation; second, groundnuts, a major island char crop, are sown relatively late in this area, and sparsely cultivated areas in the March 1993 satellite image may have been interpreted as sand when they actually are planted with groundnuts. The opposite was the case in the unprotected mainland: 88 percent of the image estimated vegetated/cultivated land was reported to be cultivated, the rest may be homesteads and orchards.

Figure 3.15 shows that a high percentage of study area land is cultivated. There are very few submerged mauzas (blue), all of which are uninhabited (pale blue in the previous figures) and were submerged during the 1993 dry season. Although pressure on land resources is high and many of the remaining uninhabited mauzas have land, they are not cultivated (yellow)—these are mainly small sandy char areas along the main river channel. The other uninhabited mauzas, most of them within the channel, have less than 50 percent of land cultivated (pale green).

In 35 percent of cultivated mauzas, more than 80 percent of land is cultivated (dark green in Figure 3.15). Cultivation is particularly extensive in the north bank unprotected mainland, and locally on the south bank of the middle and lower reaches. As expected, very few island char mauzas have much cultivated land except for a few more stable islands, such as in the middle reach.

Cropping intensity measures the extent to which land is multiple cropped in a year. A 100 percent intensity means all cultivable land grows an average of one crop per year; a 200 percent intensity means an average of two crops a year are grown.[2] Most cultivable land grows at least one crop a year in Bangladesh, and the study area is no exception. Very few cultivated mauzas have intensities up to 100 percent (pale brown in Figure 3.16), and these 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 lower reach.

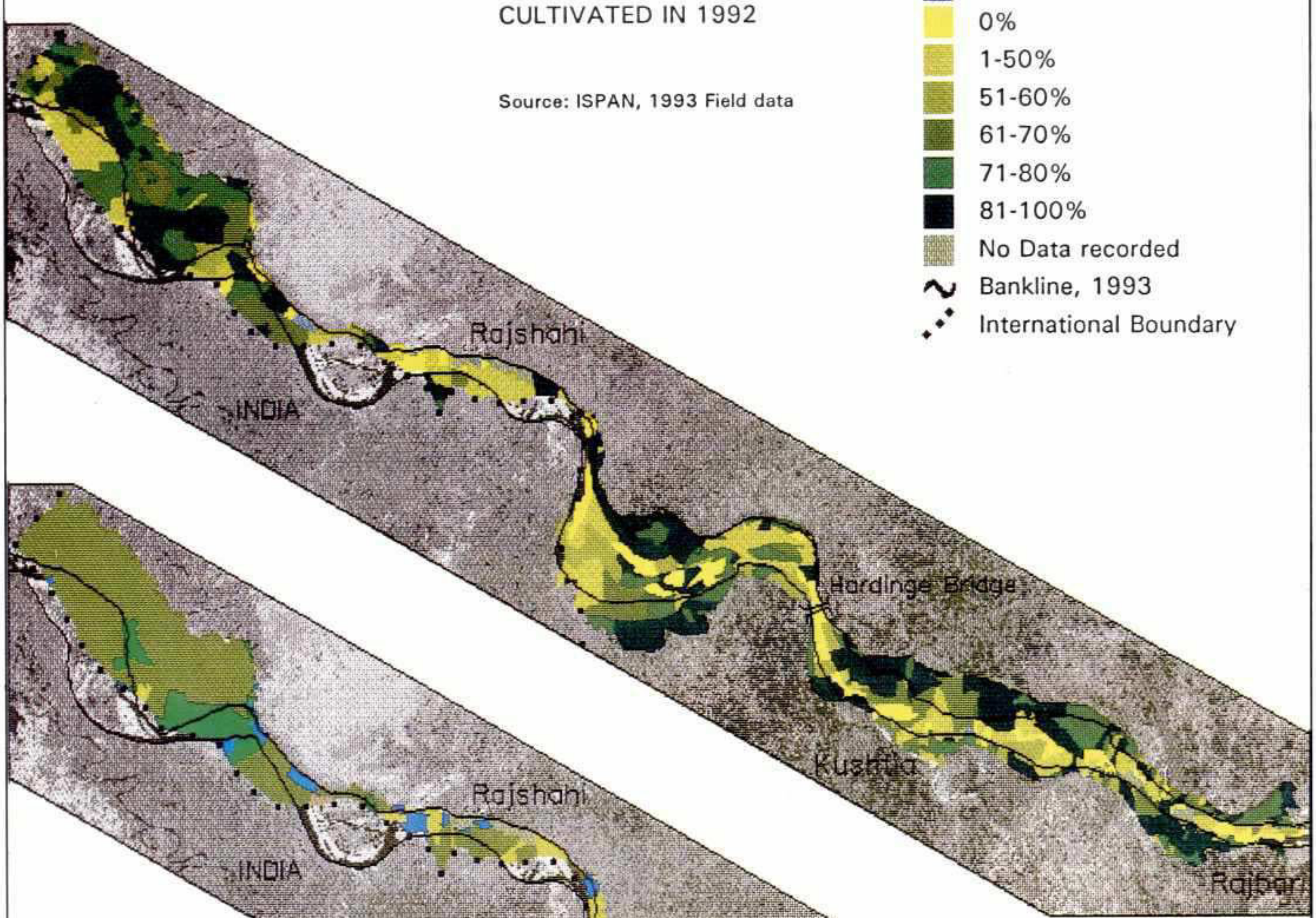
Average cropping intensities are relatively high (more than 170 percent) for all three reaches (Table 3.10), and the overall average is 185 percent. While cropping intensity is similar for all land types, local variations occur (Table B.31). Most of the area falls into the 151-200 percent category (pale green). Figure 3.16 shows that cropping intensities of more than 200 percent (darker green) are limited to small areas of the south bank unprotected mainland. This is older land, and it has had little bank erosion since 1984 (Chapter 2). By comparison, the much less stable island and attached chars of the middle reach have the lowest cropping intensities in the Ganges charlands, but this is still above 160 percent.

Table 3.10 Cropping Intensity

Land Type	Cropping Intensity (percent)
Island Char	174
Attached Char	189
Unprotected Mainland	186
All Land	185

Source: Table B.31

Figure 3.15 PROPORTION OF LAND CULTIVATED BY MAUZA



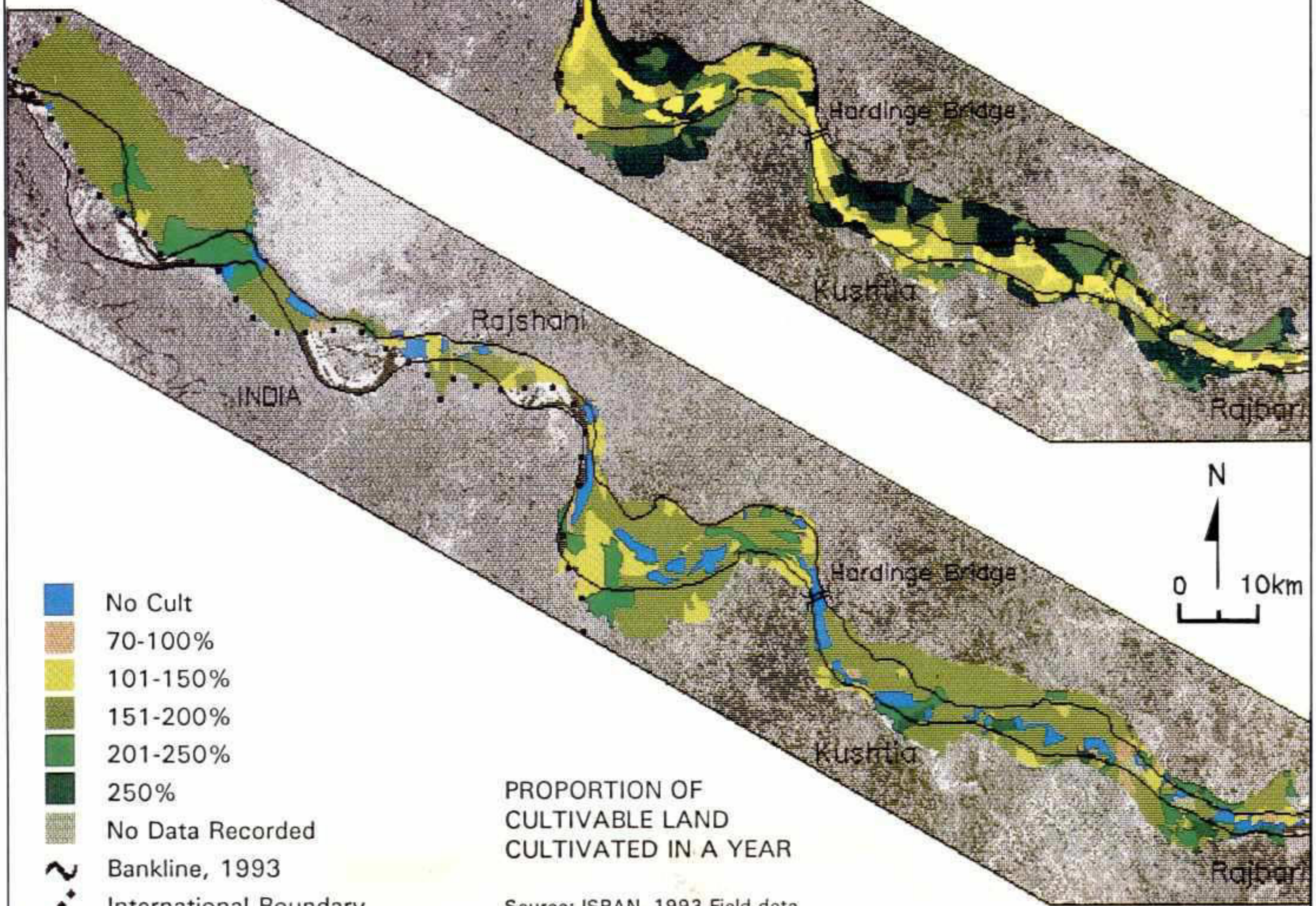


Figure 3.16 CROPPING INTENSITY

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 Ganges 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. Sandy soil was much more common than in the Meghna area: an average of 34 percent was sand (Table B.32). Mauzas with a high percentage of sandy soil are concentrated in a ribbon of land throughout the length of the main channel. Table 3.11 shows a trend almost identical to that found in the Padma; sand content ranges from maximum in island chars to minimum in setback and unprotected mainland. The middle reach, which has the most chars, also has the most sand (42 percent), while Shibganj and Nawabganj in the upper reach have the least sand. The predominantly sandy soils continue for the length of the Ganges and into the Padma where they gradually decline near the confluence.

The influence of sandy soil on cultivation should be most apparent in the extent to which dry-land crops (millets, groundnuts, or sweet potatoes) are grown. Figure 3.18 shows that these crops are absent (pale brown) from most of the upper reach and from the mainland fringe of the south bank in the middle and lower reaches—the areas without sandy soil. Some of the sandiest mauzas are uncultivated (blue), presumably because they are entirely sand. Cultivation of millets is nearly nonexistent in the Ganges chars (0.9 percent of cultivated land, Table B.33), unlike in the Jamuna chars where they are some of the most important crops. Similarly, sweet potatoes are rare in the Ganges area. Agronomic study to determine whether these crops would give good returns in the Ganges chars might be worthwhile.

Table 3.11 Percentage of Sandy Soil

Char Type	% Sand
Island Char	60
Attached Char	44
Unprotected Mainland	20
Total	34

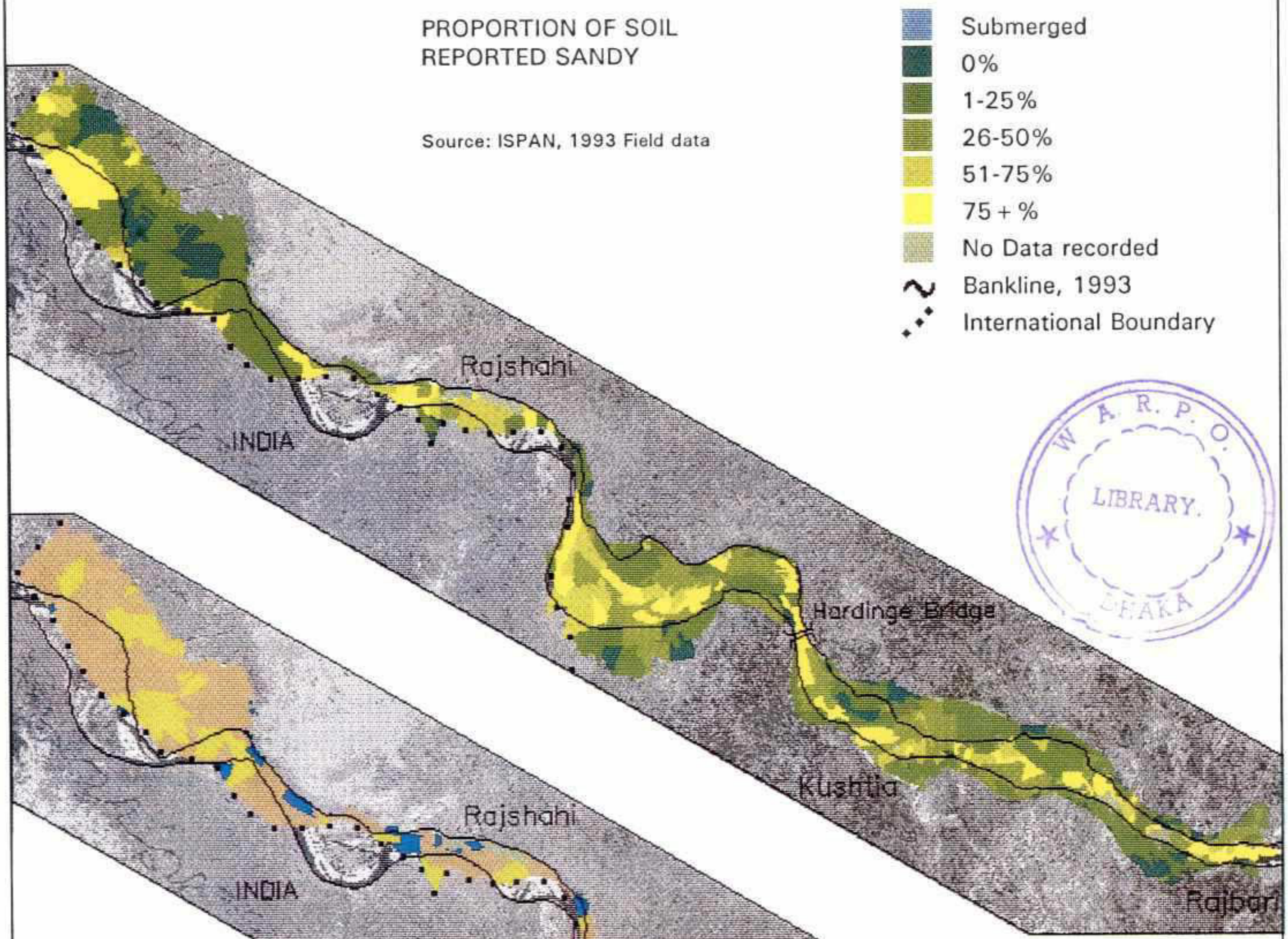
Source: Table B.32

Groundnuts are widely grown in the island chars (14 percent of cultivated land) and account for most of the dry-land crop area in Figure 3.18 and Table 3.12). They are mainly raised in the sandy char areas of the middle and lower reaches and in some of the west bank attached chars. Figure 3.18 shows that these crops are fairly important in the middle reach chars (green). Table B.34 shows lower yields than those reported in the Padma chars, which may explain the smaller area under this crop. Unlike in the Padma, however, the crop does not appear to be subject to flood damage, so further research and extension for appropriate crops and farming systems in the sandy chars of the Ganges could be of benefit.

A wide range of other crops are also grown during the winter, including wheat and other rabi crops and winter-sown boro paddy. Of these, pulses (*dal*) are the most important, particularly in the upper reach (Table 3.12). Few pulses are grown in the middle reach, where soils may be too sandy for the crop. Wheat is the next most important rabi crop and is equally important in all land types and reaches; about 17 percent of cultivated land is under wheat. Local and high-yielding varieties (HYV) of boro paddy are grown on only 15 percent of the cultivated land (less than in the Padma and Meghna charlands).

According to Figure 3.19, there are small areas of boro cultivation in the study area. As Table 3.12 shows, the type of boro differs between land types and reaches. Local boro is mainly grown in the middle reach and island chars, where presumably there are suitable low-lying areas with residual moisture and soils that are not too sandy, but even here it is not as common as in the Meghna charlands. The pale green areas in the upper reach in Figure 3.19 mainly represent HYV boro

Figure 3.17 EXTENT OF SANDY SOIL



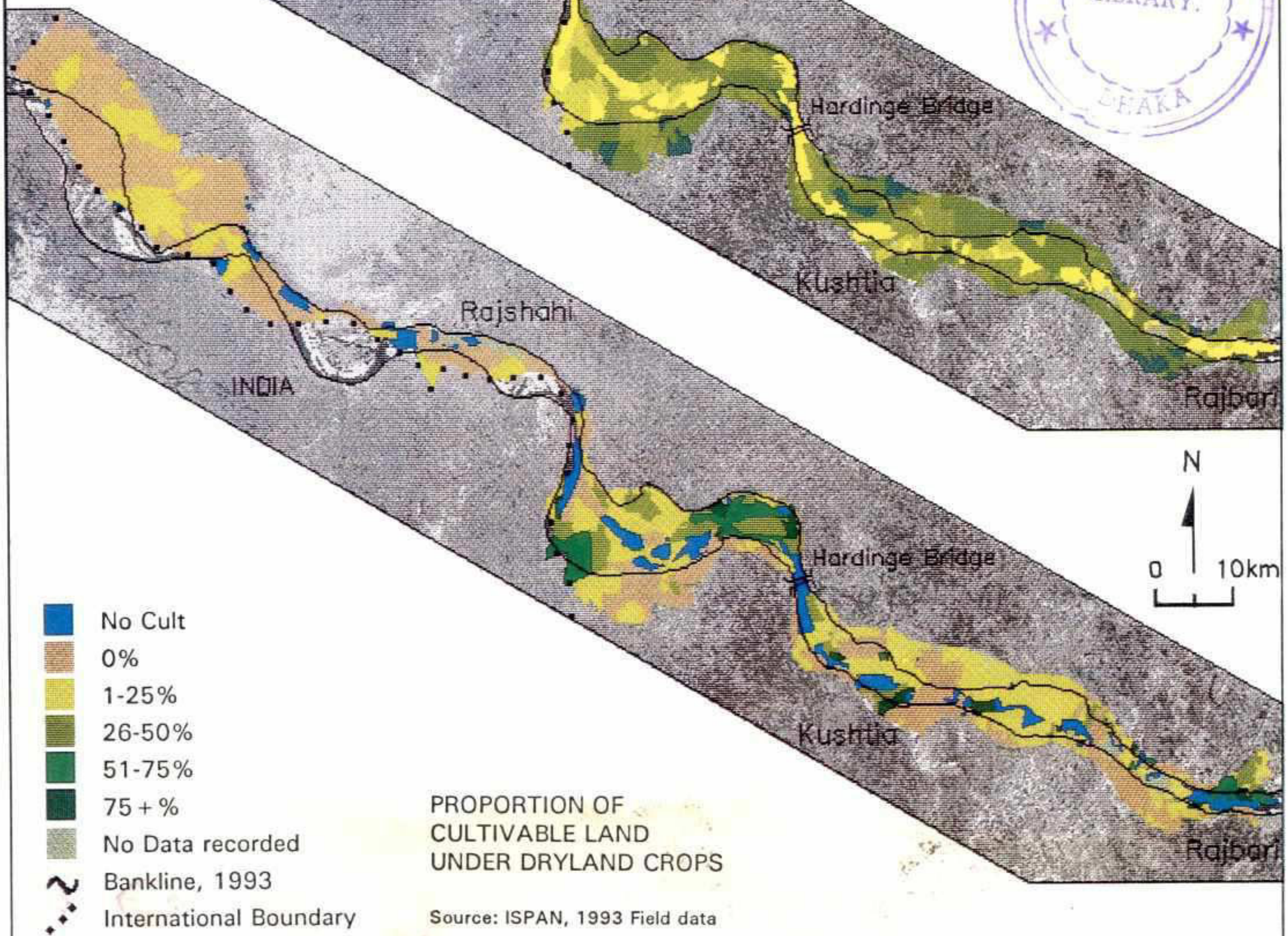


Figure 3.18 DRYLAND CROP COVER

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	23	8	4	2	16	11	8
Wheat	14	17	17	15	18	19	17
Pulses	25	38	32	49	8	28	32
Other Rabi Crops	14	17	16	13	24	15	16
L. Boro	13	4	4	2	13	5	6
HYV Boro	3	9	12	11	6	8	9
Total	92	92	85	92	85	86	88

Source: Table B.33

on unprotected mainland, although it is also grown in small areas in the other reaches. Since HYV boro requires irrigation, the data imply that such facilities are scarce in the Ganges charlands, except in the upper reach, where there is some scattered irrigation. Despite this cultivation pattern, the island chars reported slightly higher yields for HYV boro than unprotected mainland mauzas (Table B.34). The area under irrigated crops is still low, 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.

Table 3.12 shows that the remaining rabi crops are the most widely grown winter crops in the study area. The inventory did not collect data on each of the many types of pulses grown, but collectively these crops cover 32 percent of cultivated land (much more than in the other charland areas). In addition, wheat is grown on 17 percent of all land, and the remaining rabi crops cover a similar area. "Other rabi crops" comprise chilies, potatoes, oilseeds (mainly mustard and *til*), and onions; there also are very small areas producing a wide range of other spices and vegetables. Combining pulses and wheat with other rabi crops in Figure 3.20 shows that these crops are most widely cultivated in the upper reach (where pulses are grown on 49 percent of land). There are more sandy soils in the middle reach chars, but a wide range of crops, including wheat, seem to be preferred over crops most suited to these soils. The intensity of rabi/boro cultivation is somewhat higher in the upper reach, but does not differ between land types (although the proportions of different crops vary).

Unlike in the Padma chars, early flooding rarely if ever affects rabi crops in the Ganges and therefore is unlikely to inhibit their cultivation. The exception is L. boro. Table 3.13 indicates this crop can expect to be damaged about one year in every 10 based on 1988-92. This is still a fairly low risk, and is consistent with the normal rule that flood peaks occur on the Ganges later than on the Jamuna-Padma.

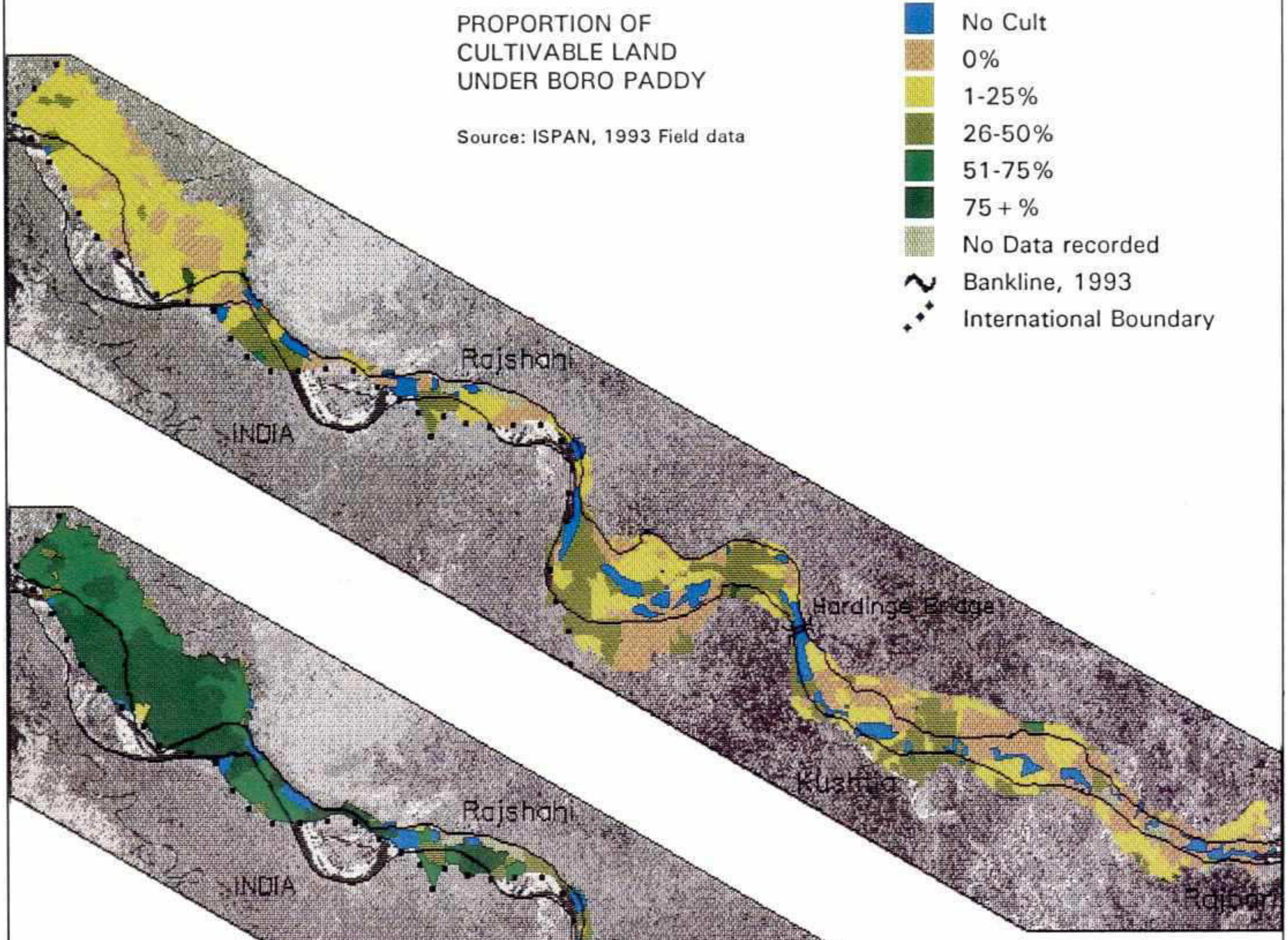
Table 3.13 Mean Number of Years in Ten with Flood Damage to Selected Crops*

Crop	Upper	Middle	Lower	Total
L. Boro	1.4	0.7	0.9	0.9
Aus	2.2	1.0	2.0	1.8
Jute	1.8	1.1	2.0	1.8
B. Aman	3.6	1.7	1.8	1.9
TL Aman	1.9	0.3	0.9	1.0
HYV Aman	1.6	0.0	0.1	0.4
Sugarcane	1.3	0.7	0.6	0.8

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.

Figure 3.19 BORO CROP COVER



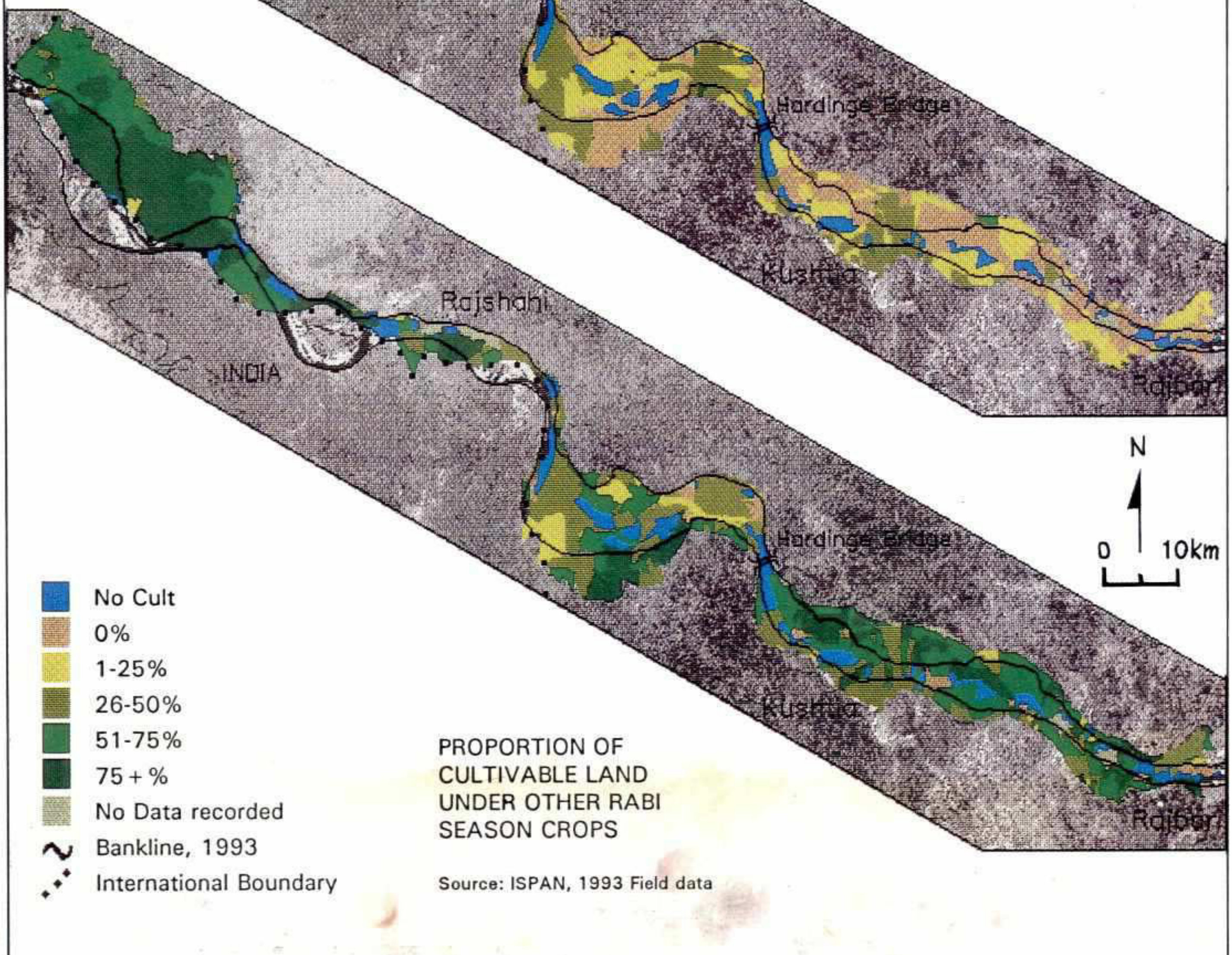


Figure 3.20 RABI CROP COVER

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*	53	64	61	78	40	53	60
Jute	10	7	10	6	14	10	9
B. Aman	6	5	10	0	11	15	8
TL Aman	1	3	3	1	2	5	3
HYV Aman	1	2	1	0	2	3	2
Sugarcane†	6	5	12	5	13	10	9
Total	77	86	97	90	82	96	91

Source: Table B.33

*Some aus is broadcast with B. aman, but because they are harvested at different times they have been counted as separate crops.

†Although its growing season is longer than the monsoon season, sugarcane is included in this table since its cultivation usually means that other monsoon season crops cannot be grown.

Cultivation is as important in the monsoon season as in the dry season, but it is dominated by just one crop. Early monsoon (aus) paddy is by far the most important crop in the Ganges charlands, covering 60 percent of all cultivable land (Table 3.14). Figure 3.21 shows a high percentage of land under aus throughout the area. The highest intensity of aus cultivation is in the upper reach (78 percent), where virtually all land in Nawabganj and Shibganj thanas grows the crop. In the middle reach, although aus is still the single most important crop, it is only grown on 40 percent of land. This is because of a more diverse monsoon season cropping pattern. Aus gives no better yields than in the other charlands, but requires relatively low inputs. The upper reach is in the region of Bangladesh that gets the least rainfall, less than 1,500 mm per year, so the concentration on aus paddy is presumed to reflect a combination of moderately sandy soils, lack of water in the post-monsoon period, and a high risk of damage to aman paddy. B. aman in the upper reach is apparently damaged more often than 3-in-10 years (Table 3.13) and is not grown in this area.[3] Although aus was reported damaged 2-in-10 years, this is only half the damage frequency reported in the upper Padma.

In the Meghna and Padma charlands, B. aman is the most important monsoon season crop, but according to Figure 3.22 it is hardly grown at all in the Ganges charlands. It is absent from the upper reach, and only grown on 11 to 15 percent of land in the middle and lower reaches (Table 3.14). B. aman cultivation in these areas is concentrated in the south bank mainland, but appears to be more common near the Jamuna confluence (in the adjacent upper Padma, 40 percent of land is under B. aman).

The inventory data are consistent with the agricultural information from the middle reach RRA, which found that aman is only a minor crop. In many of the areas where it is not grown, the RRA found, there reportedly is a high risk of damage to the crop from quickly rising floods and rapidly flowing water. Aus, on the other hand, could be harvested before such floods occur. Instead of aman, and because of the light sandy soils, farmers sow rabi crops early (in October) on residual moisture, leaving no time to cultivate aman.

Transplanted aman is higher yielding than broadcast varieties because it can be grown 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 only grown in small areas, mainly in the lower

Figure 3.21 AUS CROP COVER

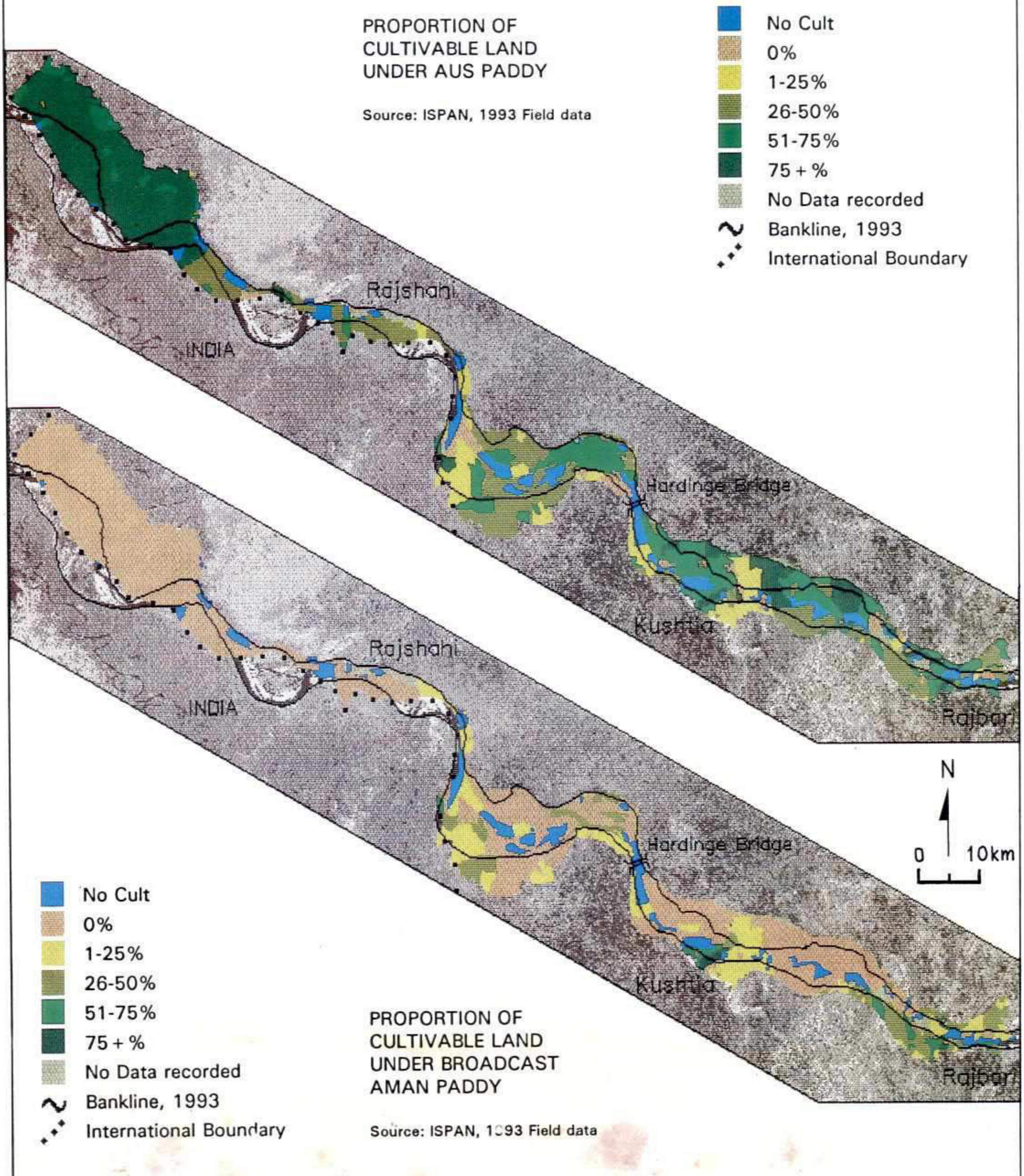


Figure 3.22 B. AMAN CROP COVER

reach on setback land and attached chars; this is also true of HYV aman. Since these crops appear not to be damaged as frequently as B. aman (Table 3.13), they are presumably only grown on the limited areas of higher land that have low flood risk.

Unlike in the other main rivers, jute and sugarcane are important crops in the Ganges charlands. Jute, grown in the same season as aus, is more or less evenly cultivated over about 9 percent of land, except that it is slightly less common in the upper reach where it competes with aus. The frequency of flood damage is the same as for aus. Sugarcane is mostly cultivated in the mainland of the middle and lower reaches (Table 3.14). Although not strictly a monsoon crop, its long growing season means that alternative monsoon crops cannot be grown on this land. It appears to be less vulnerable to flood damages (damaged just less than 1-in-10 years).

The inventory data on cropping systems reveal that the Ganges charlands differ considerably from those of the Jamuna, Padma, and Meghna. The high cropping intensity is the product of a diverse range of crops, dominated by aus, which allow double cropping and avoid risks of damage from quickly rising floods. By leaving much of the area fallow during the late monsoon, farmers can sow rabi crops as flood water recedes and make use of residual soil moisture before the charlands dry up. Irrigation facilities are limited and mainly used for boro in areas with less sandy soils. Although using river water for irrigation in the char areas might reduce vulnerability to flood damage, the costs are likely to be high in sandy soils. Farming system research in the Ganges charlands that results in increased and stabilized incomes would help char farmers. The available information indicate that the focus should start with improving yields in the early monsoon, possibly by supplemental irrigation for quick growing HYV aus, which could also be used for higher value winter crops.

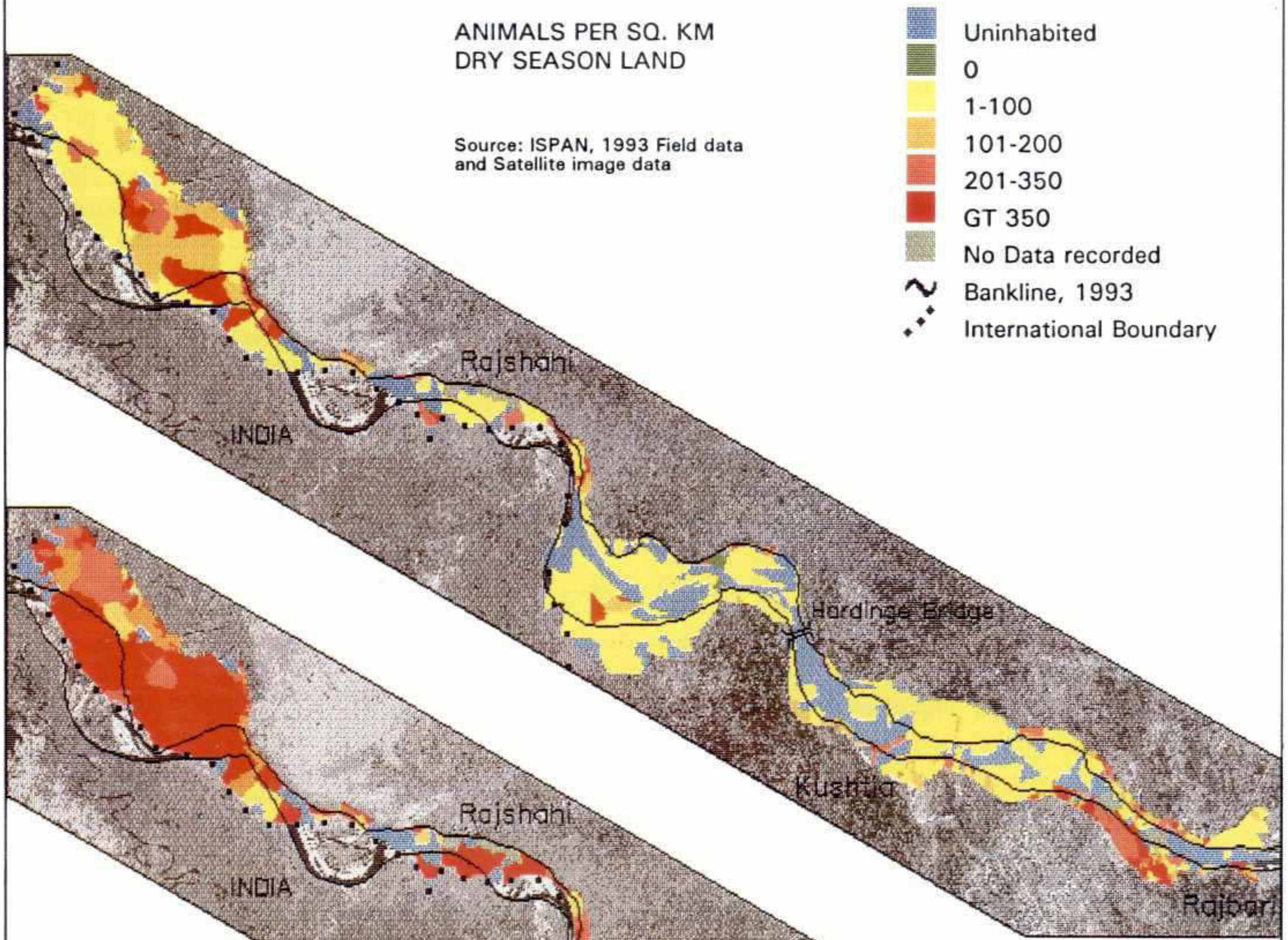
3.5.3 Livestock

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 changes somewhat between the dry and monsoon seasons (Tables B.36 and B.37). A total of just over 146,500 cattle and buffaloes were reported in the study area in the 1993 dry season, but there had been about 124,900 in the previous monsoon (85 percent of the dry season number). This is consistent with the middle reach RRA, which found that although there was some seasonal livestock fattening, this business was less widespread than in the Meghna charlands. The extent of normal monsoon flooding and poverty of many char dwellers in this area may limit the opportunity to make use of natural fodder resources (catkin grass) to raise cattle. 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 110 animals per km^2 of dry season land (Tables B.38 and B.39) in the study area. Large livestock density is highest in the unprotected mainland, particularly the upper and lower reaches (205 and 187 per km^2, respectively). These areas show up as two concentrations of livestock: on north bank attached chars and mainland in Nawabganj Thana and on the south bank mainland of the lower reach in Pangsha Thana (pink and red in Figure 3.23). High livestock densities are associated with high population densities in these areas (Figure 3.6), as well as 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

Figure 3.23 DENSITY OF LARGE LIVESTOCK TO LAND AREA



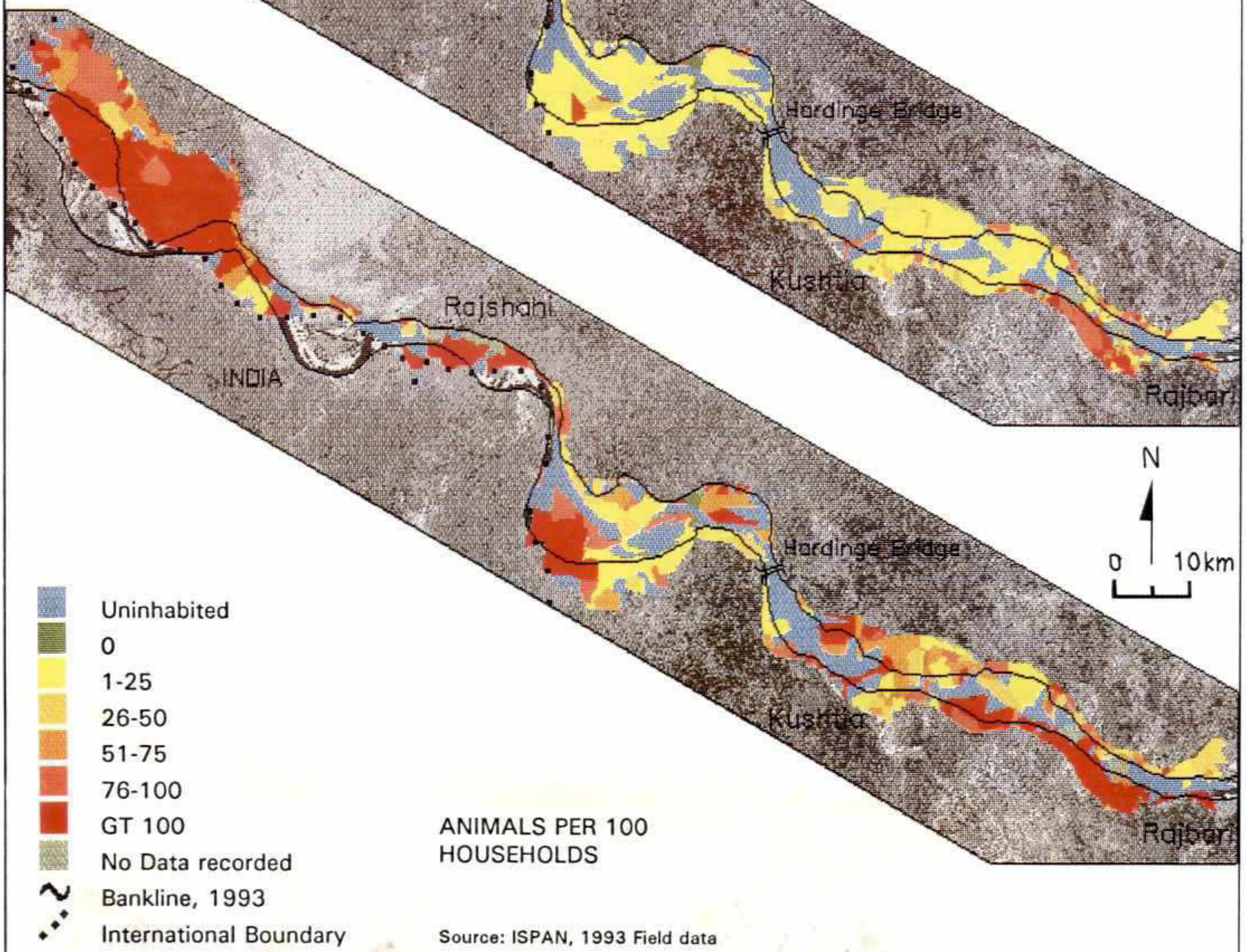


Figure 3.24 LARGE LIVESTOCK PER 100 HOUSEHOLDS

much higher livestock density in the upper reach may also be a consequence of cattle trading.

Since human population density is low in the Ganges charlands, there are more large livestock per household than in the other rivers: generally just over one animal per household (Figure 3.24; Tables 3.15 and B.40). Livestock ownership is lowest in the middle reach and on the north bank of the lower reach (yellow in the figure). Livestock ownership in the island and attached chars is about the national average (Table 3.15), but is much higher in the upper reach (1.6 cattle per household, but with many mauzas above 2 cattle per household, red in Figure 3.24). This is a stable area of mainland with some chars, where there may be more grazing. The main reason for high cattle ownership may be the need for draft power as cropping intensity in the area is high. In the other places where cattle ownership is high there are nearby charlands with low population densities and more grazing land available. There, the owners may be concentrated in the unprotected mainland.

Embankments in the Ganges mainland areas, which act as flood refuges for cattle, are close to many of the inhabitants of setback areas, and in many cases they may be accessible by land. In the island chars, however, high land is scarce or absent (particularly in the middle reach), and it may be necessary to use boats to evacuate livestock to mainland embankments during floods. Little regular seasonal movement of cattle between chars and mainland seems to occur: even in the island char mauzas there is only a 15 percent decrease in cattle numbers between the monsoon and dry seasons. Local assessment of arrangements for safeguarding livestock in floods and of seasonal livestock numbers and distributions is needed for planning cattle shelter arrangements in the Ganges charlands. Such measures might be beneficial in the middle reach and some villages in the lower reach, but there may be a high risk of erosion in these island chars.

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 marked differences between reaches in the number relative to dry season land area: 156 per km^2 in the upper reach, only 28 per km^2 in the middle reach, and 98 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 same areas as large stock: unprotected mainland and attached chars of the upper reach and the lower south bank of the lower reach. Table B.43 shows that small stock ownership showed the same trend: 1.5 animals per household in the upper reach, 0.4 per household in the middle reach, and 1.0 in the lower reach. Small stock ownership is slightly above the national average, particularly in the chars (Table 3.14). Grazing resources appear to be particularly under-used in the middle reach, where high flood risk may limit the numbers of small stock.

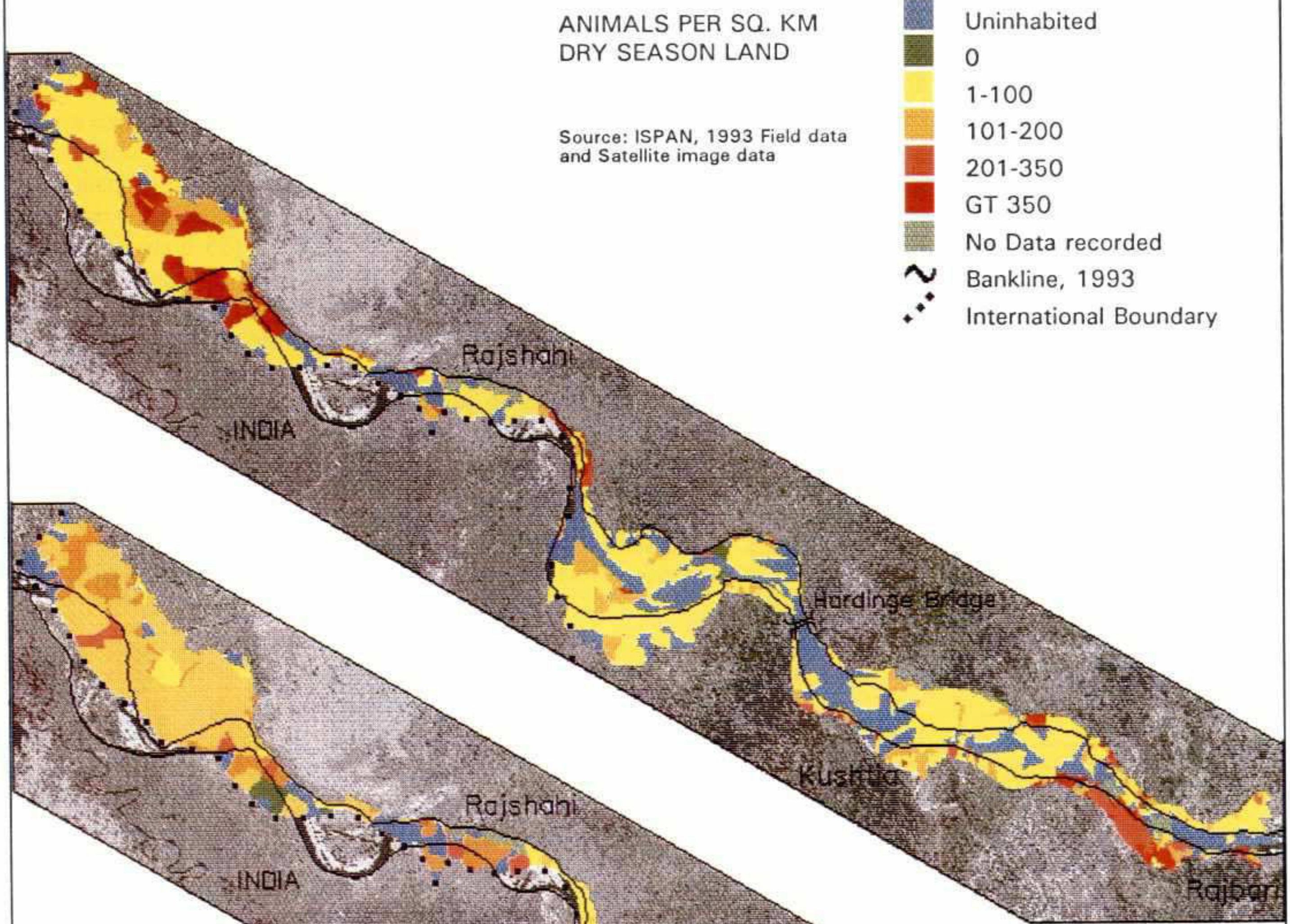
Table 3.15 **Livestock Ownership Per Household**

Land Category	Large Livestock	Small Livestock	Poultry
Island Chars	1.24	1.22	3.89
Attached Chars	1.54	1.38	4.38
Unprotected Mainland	1.08	1.03	3.51
Charland Average	1.19	1.11	3.72
Bangladesh Average*	1.33	0.96	4.99

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

Poultry numbers in the area are reported to average about 3.7 birds per household, lower than the national average (Table 3.15). Poultry ownership per household shows the same pattern as for other types of livestock, but with less variation (Figure 3.26). As with other livestock, ownership is lowest in the middle reach (yellow), where there are 2.6 birds per household (Tables B.44 and B.45).

Figure 3.25 DENSITY OF SMALL LIVESTOCK TO LAND AREA



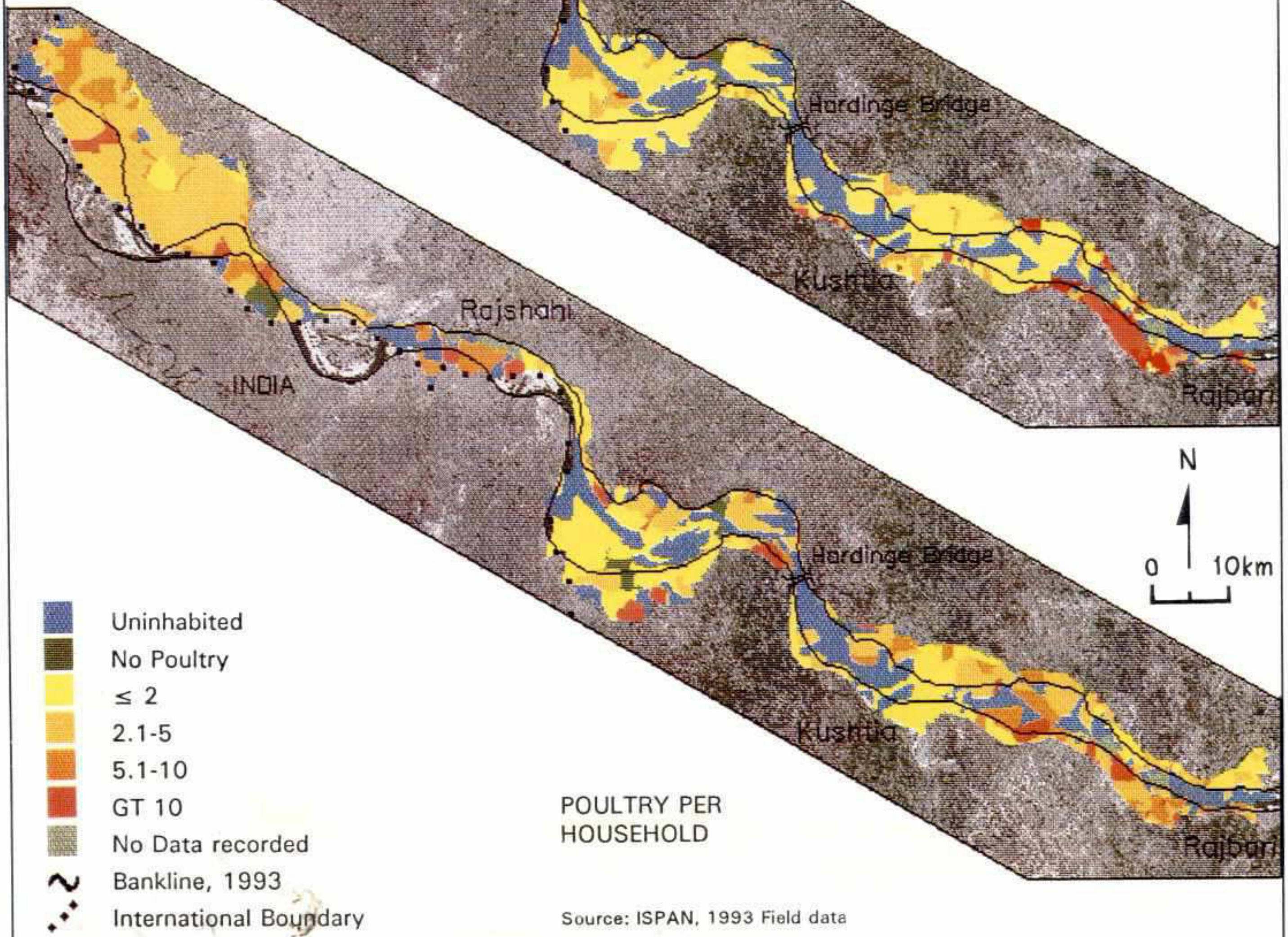


Figure 3.26 NUMBERS OF POULTRY PER HOUSEHOLD

3.5.4 Boat Availability

Small, non-mechanized boats are a vital household resource in the chars, both as a means of transport in the monsoon and for saving lives 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 3.21 shows that there is a moderate level of boat ownership in the Ganges study area. The highest ownership levels (red and dark red) are concentrated in the island chars and along the main channel. Some of the attached chars are separated from the mainland by secondary channels that join the Ganges, so boats are important for monsoon season communications in these areas, but many of the channels dry up in the dry season.

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 found that there are 19 households per non-mechanized boat (Table 3.16). Boat ownership is highest in the island chars (9 households per boat), but lowest in the middle reach (29 households per boat), where there are few boats in the mainland areas (Tables B.46 and B.47).

Although boats are a source of employment for very few study area households, since the late 1980s mechanized boats have become increasingly important as a means of transport in riverine areas, including the Ganges (Charland Study RRA surveys). Mechanized boats have helped improve the reliability of monsoon 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 quite widely available along the main river channel. There are more mechanized boats on island chars than other areas (55 households per boat; Table 3.16), especially in the upper reach where there are only 35 households per boat in island chars. These areas are mainly red in Figure 3.28. The lowest ownership is in the mainland in all reaches but particularly in the middle reach (Tables B.48 and B.49), where there are an average of more than 400 households per boat.

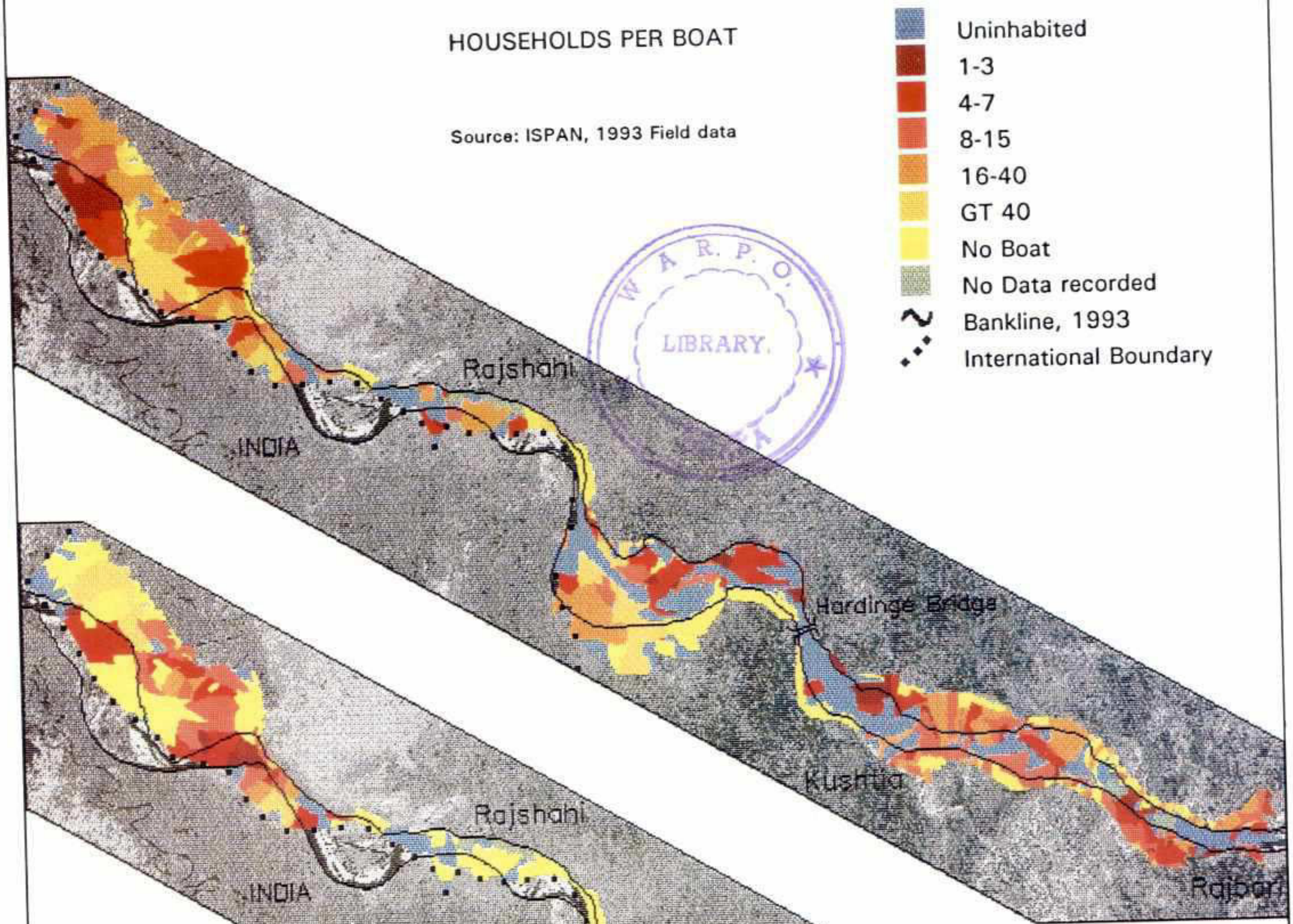
Table 3.16 Boat Availability

Land Category	Non-mechanized Boats (no.)	Households Per Non-mechanized Boat	Mechanized Boats (no.)	Households Per Mechanized Boat
Island Char	1,122	9	177	55
Attached Char	1,901	13	280	90
Unprotected Mainland	3,405	26	440	201
Total	6,428	19	897	138

Source: Tables B.46 to B.49

Figure 3.28 highlights the mauzas within the banklines without mechanized boats (yellow); some attached chars in the upper reach, the river near Rajshahi, and the south bank of the middle reach appear to be particularly badly served by mechanized boats. Even so, 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.

Figure 3.27 HOUSEHOLDS PER NON-MECHANIZED BOAT



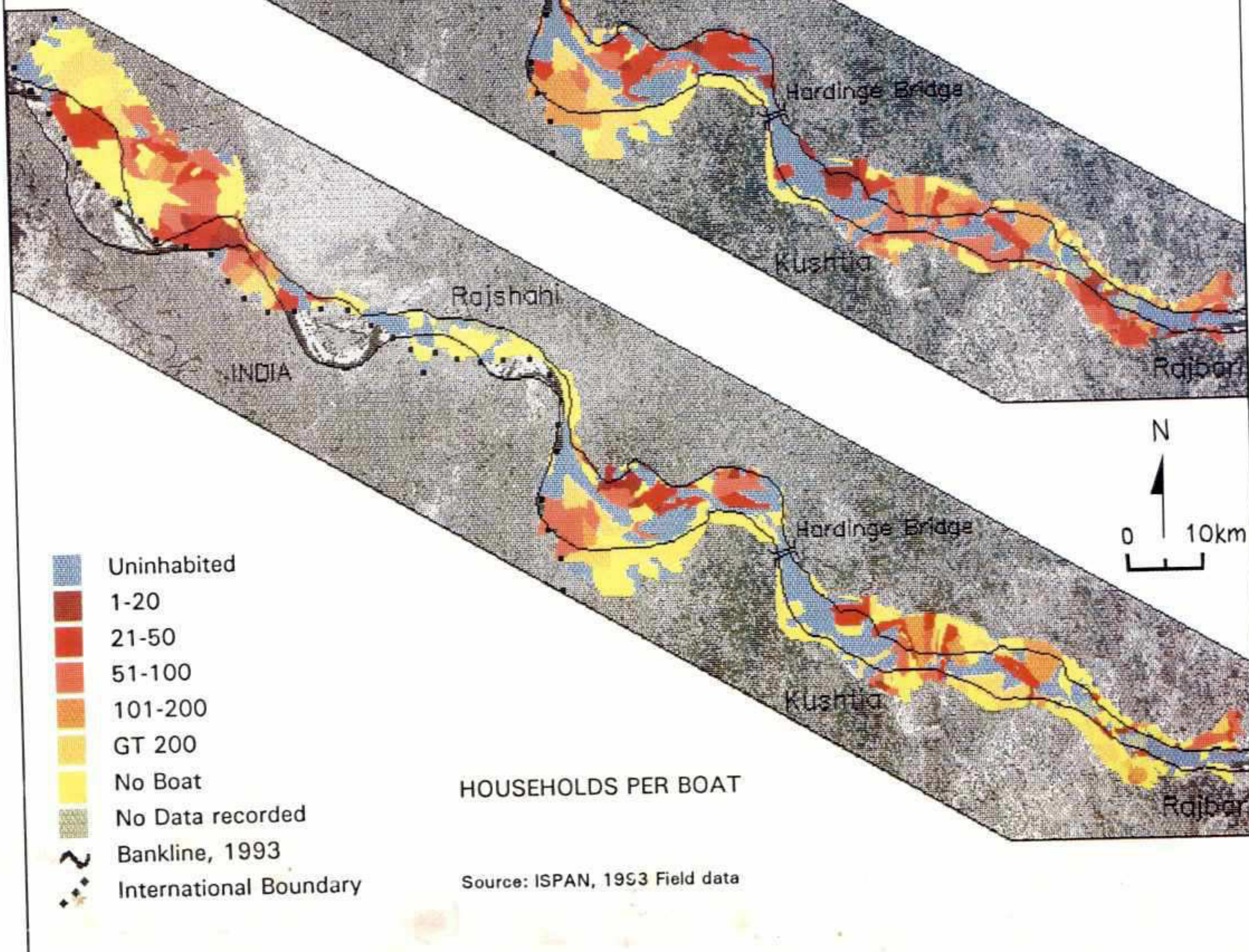


Figure 3.28 HOUSEHOLDS PER MECHANIZED BOAT

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 49 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 middle and lower reaches—68 and 55 percent of mauzas, respectively, compared with only 31 percent in the upper reach (Table B.35). Not only has bank erosion occurred in the upper and middle reaches (Chapter 2), but there also have been considerable within-bank changes involving erosion and accretion of chars; these events probably caused conflicts. The reaches with the most problems have larger areas of dynamic chars. Strife was reported to have arisen in more island chars than are presently inhabited, while 64 percent of attached chars and 31 percent of unprotected mainland mauzas had disputes (Table 3.17). Disputes do not correlate with population pressure; the highest population densities are in the mainland. Violence was reportedly common, occurring in 51 percent of mauzas with disputes, but deaths were uncommon.[4]

Table 3.17 compares the severity of disputes for char land types. Land disputes are clearly very common in island chars, often involving violence and outsiders. The pattern is similar in attached chars. The middle-lower reach RRA found that people frequently move as land erodes and accretes. Many people on island chars in the Ganges are tenants of absentee landowners, and the land in some of the island chars is reported to be controlled by a few landlords. Problems can be expected to continue, as the river course continues to wander and meander (see Chapter 2).

Some areas of the Ganges chars have been settled in the past, so that there are landowners, but there is considerable *khas* land. The RRA found that most of it was under the control of the descendants of feudal landlords and has been forcibly occupied. Violent conflicts were reported to erupt over harvesting crops and between groups of settlers organized from outside by landlords.

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 in resolving difficulties. Any development programs or flood proofing measures for the Ganges chars would need to be carefully planned to avoid being undermined by conflicts and to take account of the existing power structure.

Table 3.17 Percentage of Mauzas Reporting Land Disputes*

Type of Dispute	Island Char	Attached Char	Unprotected Mainland	Study Area
Any Dispute	100†	64	31	49
Outsider Involvement	89	49	10	24
Violence	100†	53	17	36
Deaths	9	6	2	4
Inhabited Mauzas	45	83	294	422

Source: FAP inventory

*Information covers recent years.

†Disputes were reported in some presently uninhabited mauzas in the island chars, where there are 98 uninhabited mauzas (including submerged mauzas). In 63 of 143 island char mauzas, some dispute was reported, and in 50, violent disputes were reported.

HAZARDS

3.6 Hazards

3.6.1 Health Hazards and Loss of Life

Disease, in epidemic form, has been the primary cause of human deaths among the hazards investigated, but has not been as big a problem as in the other riverine chars. Averaged over five years the incidence of epidemic deaths every year is 22 per 100,000 people. By comparison, 33 deaths per 100,000 people were attributed to the 1988 flood. 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. The hazards covered in the survey 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. Of the hazards investigated in the Ganges charlands only the 1988 flood and epidemics were reported to have caused deaths. In the lower reach fewer mauzas appear to have had deaths caused by hazards (yellow in Figure 3.29).

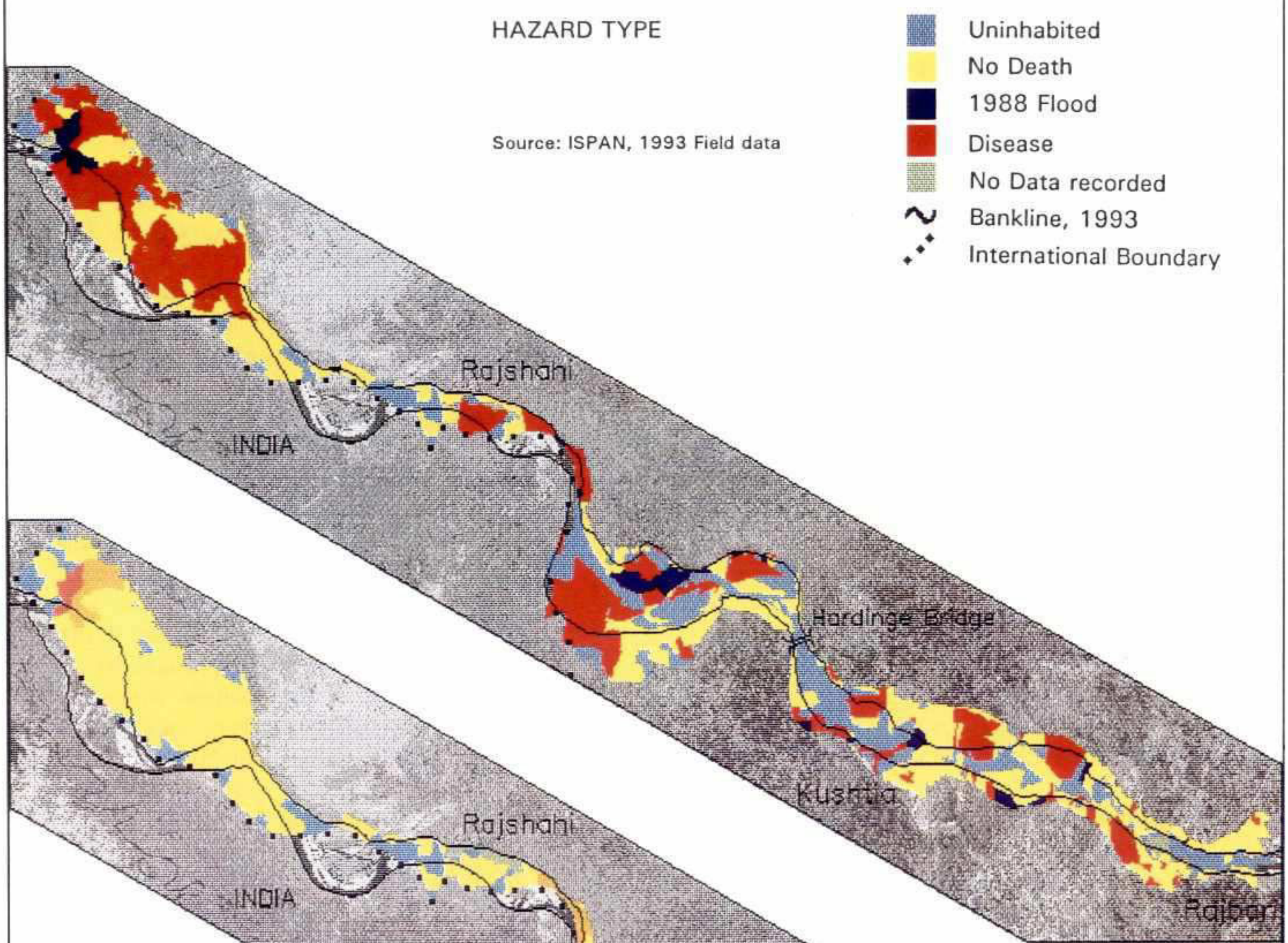
The number of deaths attributed to the 1988 flood are shown separately in Figure 3.30.[5] Those 231 deaths were concentrated in the middle reach on the island chars and north bank mainland (Figure 3.30; Table B.50), where an average of more than 200 deaths per 100,000 people occurred. There were virtually no flood related deaths in the upper reach in 1988 except for a small area in Shibganj. In the middle reach, by comparison, there were 51 percent of such deaths. The pattern, then, is consistent with the information on flood extent and impacts in Sections 3.6.2 and 3.6.3, which show that the middle reach was worst affected by the 1988 flood. Relative to the 1993 population (since the 1988 population is unknown), the reported death rate was highest in the middle reach: 100 deaths per 100,000 people (Table B.51). By comparison, the upper reach reported 11 deaths per 100,000 and the lower reach had 29 deaths per 100,000. Figure 3.30 indicates a concentration of mauzas in the middle reach (red) where improvements in flood warning and response, including flood shelters, might have saved lives. It is possible that the depopulation reported in this area between 1981 and 1993 was related to the severity of the 1988 flood impacts. Detailed local study is needed to discover the reasons for these deaths and what flood proofing measures are needed now.

Deaths due to disease and epidemics have been much more widespread, affecting large parts of the upper reach, but with the highest incidence in the middle reach (Figure 3.29; Tables B.52 and B.53). These are the same areas that reported most flood deaths in 1988.

The middle reach has fewer health care facilities than other reaches (8 percent of inhabited mauzas have a facility), which may have been a factor in the high number of deaths from floods and epidemics. Following the 1988 flood there may have been epidemic outbreaks of diarrhoeal diseases in this area, brought on by drinking contaminated river water (Section 3.4.3 showed that most people were forced to drink river/flood water during the flood). Given the problems of health care access from the island chars, that this border area is remote from government services, and that the reach has a history of relatively severe flooding (Section 3.6.2), the middle reach appears to be a priority area for improving health care, particularly during floods.

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. Improvements to help people cope with floods are more needed in the middle reach. One component of flood-time health protection must be to prevent the widespread ill effects of drinking river water (see Section 3.4.3).

Figure 3.29 HUMAN DEATHS BY PREDOMINANT HAZARD TYPE



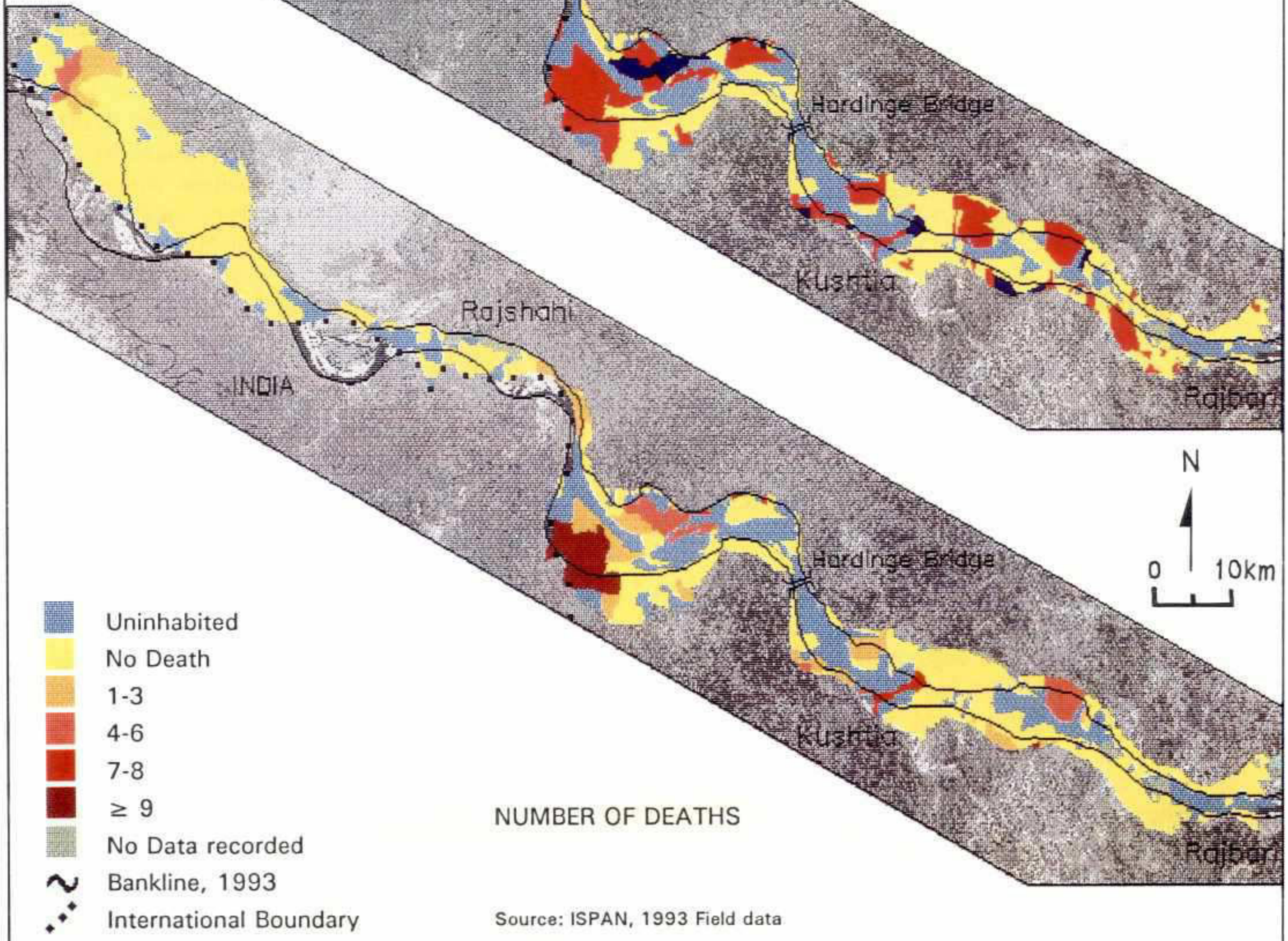


Figure 3.30 DEATHS DUE TO 1988 FLOODING

3.6.2 Recent Flood Experience

Estimates of flood extent and duration were collected in each mauza for each year from 1987 to 1992, a period that spans two high flood years (1987 and 1988), three more 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	48	97	71	62
Middle	98	100	87	85
Lower	90	100	76	72
Total	74	99	76	70

Source: Tables B.46, B.48, B.50, B.52
*Mean percentage for four years

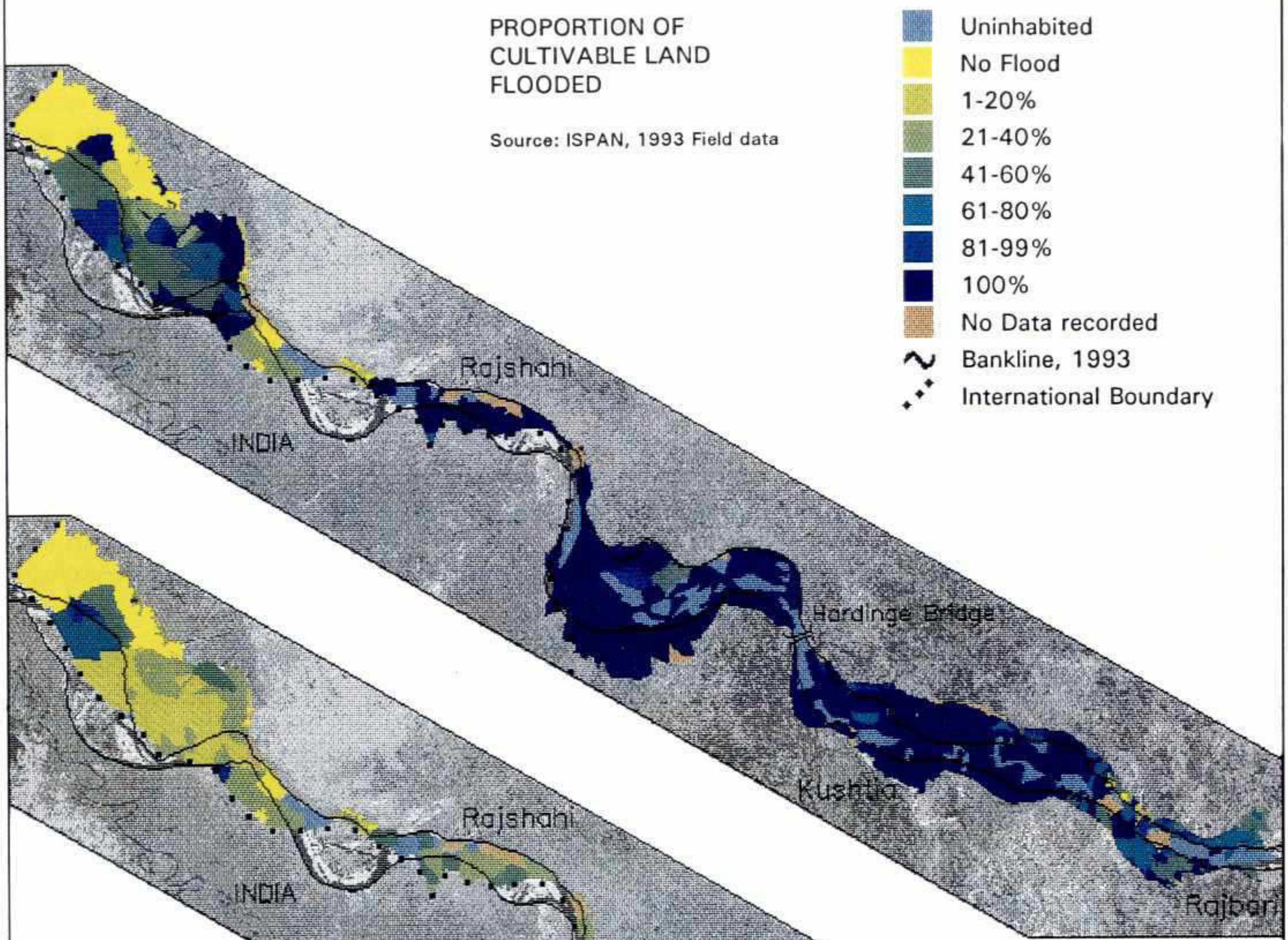
In order to standardize the inventory estimates, key informants were asked to estimate the percentage of cultivable land underwater at the peak water level in each year and the number of days that land was submerged. Estimates of flood duration are probably more variable than those for extent, due to differences in interpretation between informants, but they are intended to show the number of days during which the extent of mapped flooding lasted. Informants in some mauzas 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).

Since the absence of cultivation generally correlates with submergence, the uninhabited and uncultivated mauzas are presumed to have already been underwater during the flood season in the relevant years. Therefore, they are colored pale blue and 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, the average is for three years (1990-92).

Figure 3.31 shows that in 1987 the most extensively flooded areas were in the middle and lower reaches, where more than 90 percent of land was flooded. All land in the middle reach attached chars was reported to have been flooded in 1987 (Table B.54). In the whole study area, 74 percent of cultivable land was underwater in that year. A large area of Shibganj Thana in the upper reach was not flooded (yellow), and in that reach only 48 percent of cultivable land was underwater (Table 3.18). This part of the Ganges study area is not bounded by an embankment. A few mauzas along the riverside in this area were only settled about 1987, so respondents may have reported no flooding because they had no direct experience of 1987, but the reasons for this apparent lack of flooding deserve further investigation. Flooding also appears to have been slightly less extensive close to the Jamuna confluence.

Duration of flooding in 1987 follows a similar pattern. Figure 3.32 shows that mauzas where the flood lasted more than 40 days (dark blue) are concentrated along both banks in the middle reach and in the upper half of the lower reach. Flooding in island chars averaged at least a week longer than in attached chars and mainland (Table B.55), but this is partly because a high percentage of this land is in the middle reach. Average duration, with little variation between land types, was 42 days in the middle reach. This is just over four weeks longer than in the upper reach, where land was only flooded for two weeks (pale green; see Table 3.19). Flooding duration in the lower

Figure 3.31 PEAK FLOOD EXTENT 1987



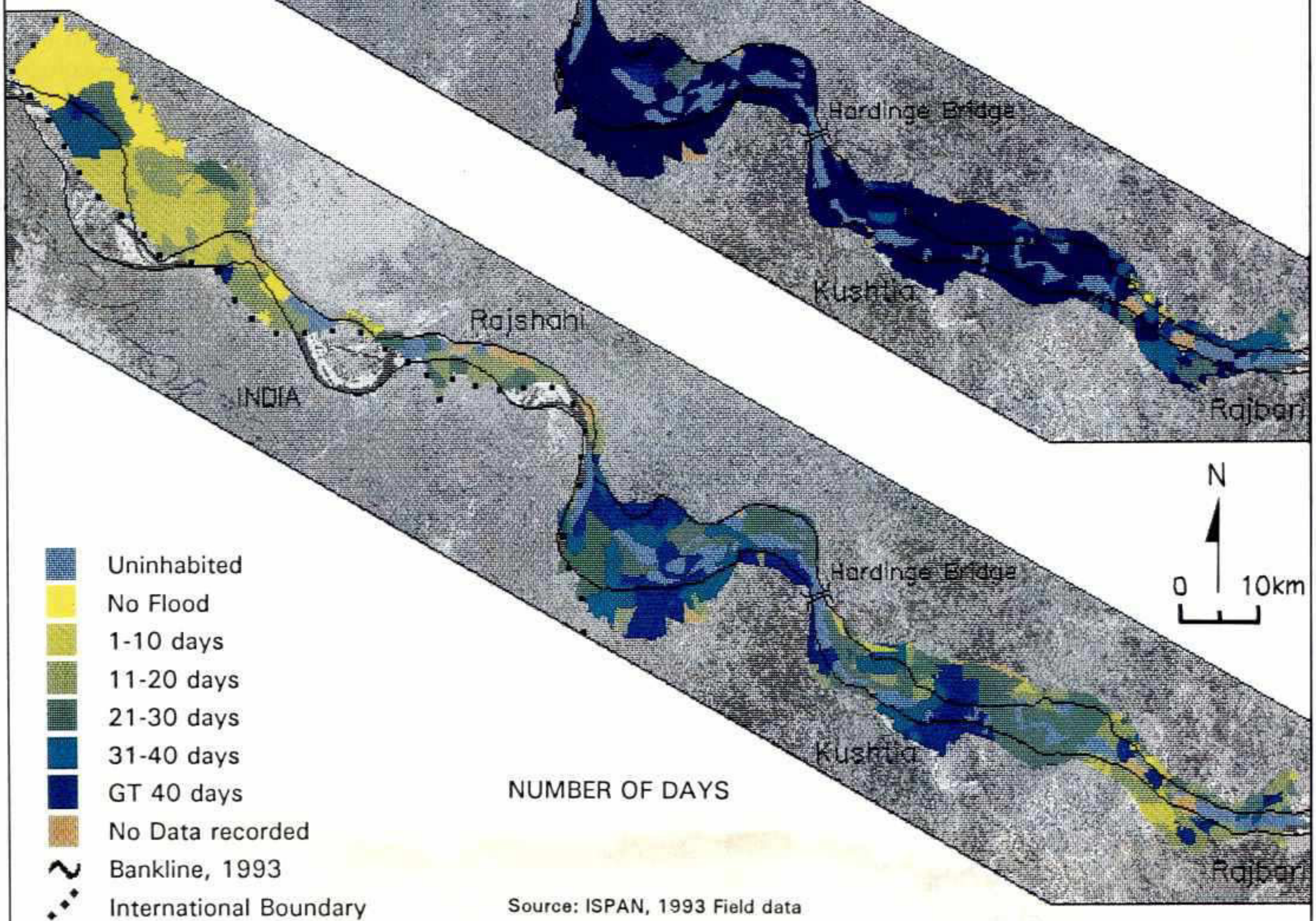


Figure 3.32 PEAK FLOOD DURATION 1987

Table 3.19 Duration of Flood by Reach (days)

Reach	1987	1988	1991	1989-92*
Upper	13	30	17	16
Middle	42	49	29	29
Lower	28	39	21	20
Total	27	39	22	21

Source: Tables B.47, B.49, B.51, B.53
*Mean duration for four years 1989-92

reach was between these two extremes, averaging four weeks in length. The middle reach was flooded longer than the Padma charlands, but shorter than the Upper Meghna.

Figure 3.33 shows that virtually all cultivable land in the study area was flooded in 1988 (99 percent flooded). Only in the attached chars and unprotected mainland of Nawabganj was a small amount of farmland above water at the peak of the 1988 flood. This is consistent with 1988 being a much more severe flood, presumably where flood damage to monsoon crops occurred in only one year (as with aus in the middle reach) the damage occurred in 1988.

Figure 3.34 shows that flood durations were longer in 1988 than in 1987. The pattern shown is similar to that in 1987, but the more uniform pattern indicates a greater increase in flood duration in the upper and lower reaches. Flooding in the study area lasted an average of 12 days longer than in 1987 (average of 39 days). The increase in duration in the middle reach was only 5 days (a 12 percent increase over 1987), compared with more than two weeks of additional flooding in the upper reach (130 percent increase over 1987). Island chars tended to be flooded for slightly longer than unprotected mainland. Figure 3.34 shows that flooding persisted for longer where the charlands are widest. In the two extensive areas where the within-bank width is narrowest (near Rajshahi and near Rajbari), duration was much lower. A confinement effect, retaining flood water in the chars of the broad middle reach, may occur as a result of the extreme narrowing of the active floodplain at Hardinge Bridge.

According to Table 3.18, flooding was slightly more extensive in 1991 than the average for 1989-92, mainly in the unprotected mainland of the upper reach (81 percent flooded compared with a four year average of 66 percent flooded, Table B.58). In this area, the 1991 flood appears to have been worse than that of 1987. Some of this difference could possibly be due to flooding from the Mahananda River, which joins the Ganges in this reach (Shibganj and Nawabganj thanas form part of the lower Mahananda floodplain agro-ecological zone).

Flood duration in 1991 was 18 percent shorter than reported in 1987, but 44 percent shorter than in 1988 (Tables 3.20 and B.59), and it did not differ from the 1989-92 average. These results are consistent with the water level records for 1991, which indicate only a normal monsoon peak flow.

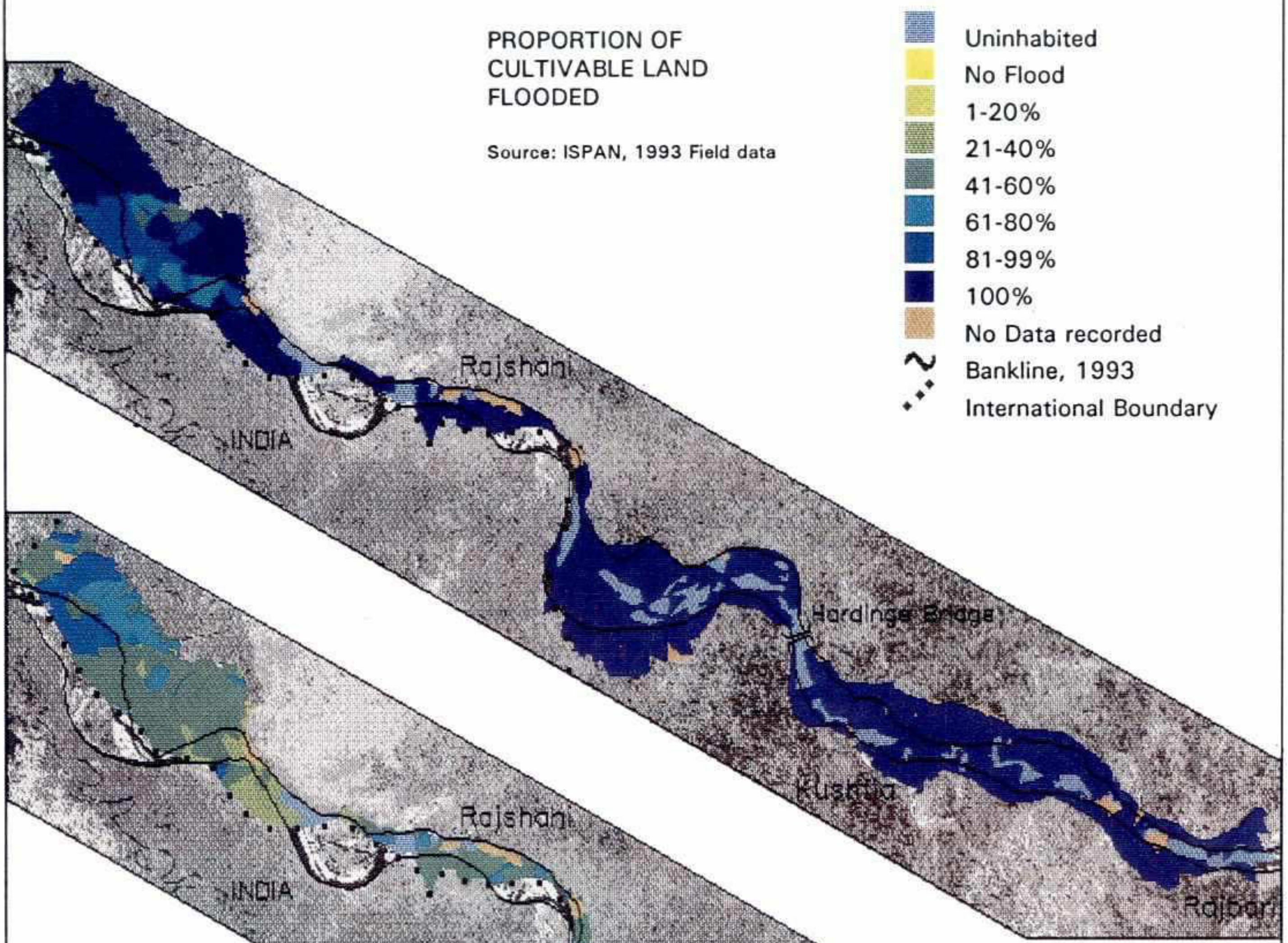
Average flood extent and duration for the four years 1989 to 1992, since these were not severe or unusual flood years for the Ganges, should be a good indication of normal monsoon conditions. Extensive flooding of cultivable land is normal in

Table 3.20 Percentage of Land Flooded by Char Type

Char Type	1987	1988	1991	1989-92*
Island Char	90	100	88	83
Attached Char	81	98	66	65
Unprotected Mainland	64	99	78	69
Total	74	99	76	70

Source: Tables B.46, B.48, B.50, B.52
*Mean percentage for four years 1989-92

Figure 3.33 PEAK FLOOD EXTENT 1988



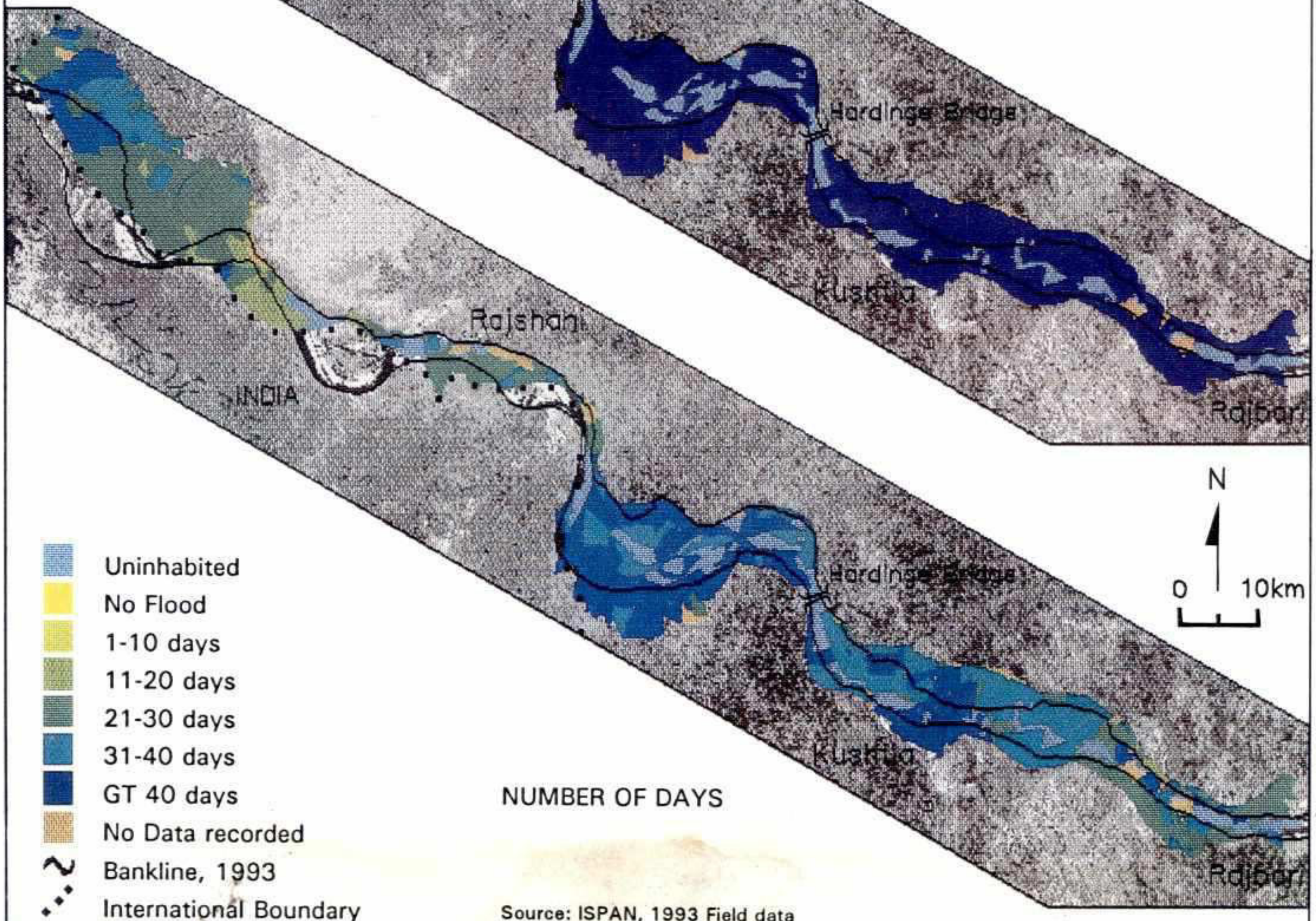


Figure 3.34 PEAK FLOOD DURATION 1988

much of the study area, particularly in the island chars and the wider reaches of the river (where the majority of the island char mauzas are concentrated). These areas are blue in Figure 3.35. The figure indicates that the restricted area of charland along the Ganges is mostly flooded (70 percent) even in normal monsoons. This is true even in the upper reach, which has the only extensive area of unprotected mainland—66 percent of this land was underwater on average in the peak of each monsoon from 1989 to 1992.

Table 3.21 Duration of Flood by Char Type (days)

Char Type	1987	1988	1991	1989-92*
Island Char	35	44	27	26
Attached Char	27	38	22	21
Unprotected Mainland	24	37	20	19
Total	27	39	22	21

Source: Tables B.46, B.48, B.50, B.52
*Mean duration for four years 1989-92

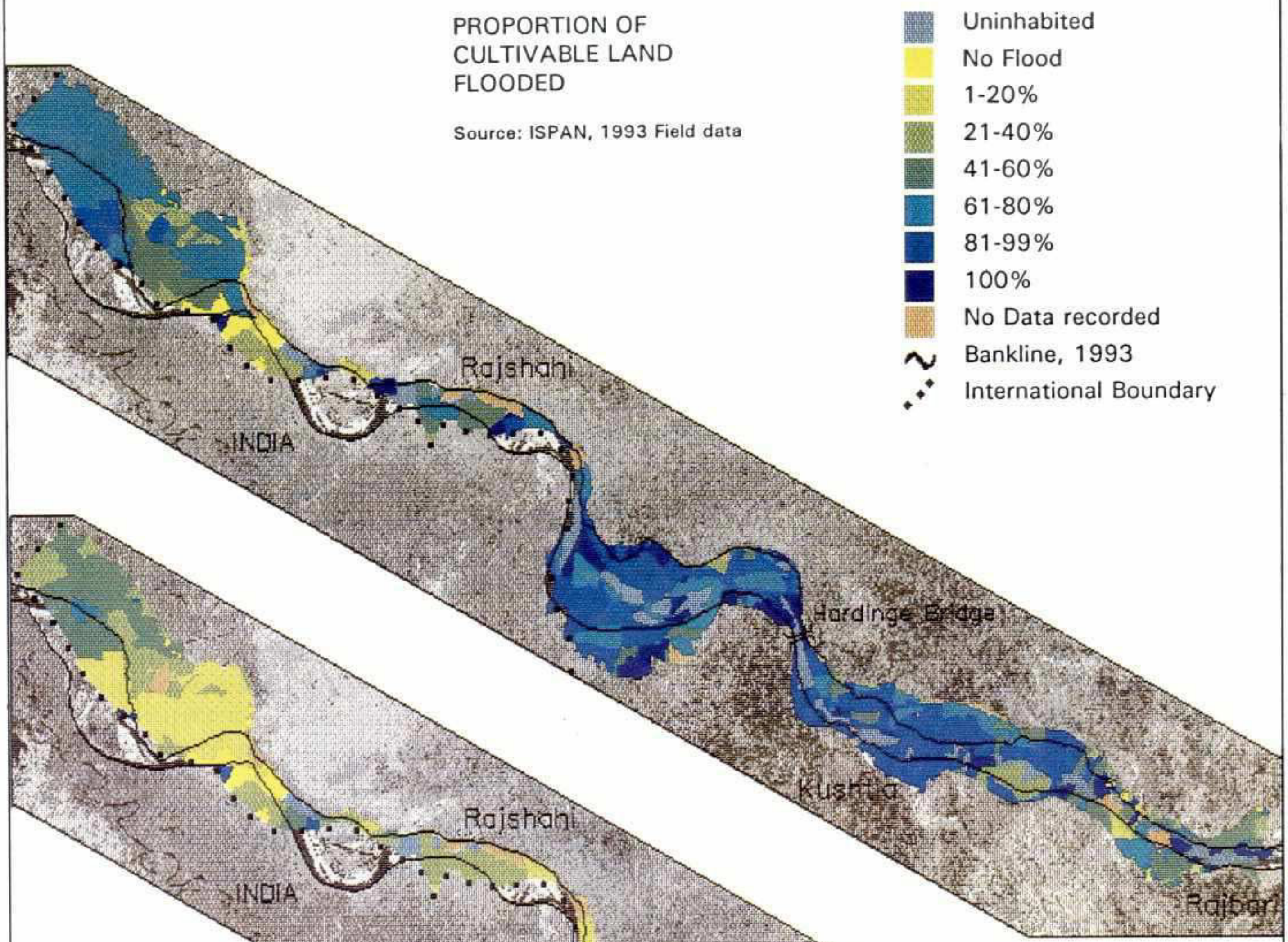
Island chars are normally 83 percent underwater in the monsoon (Table 3.20), and more than half the island char area is in the extensively flooded middle reach. During normal monsoon flooding there is apparently some higher flood-free land near Godagari and Rajshahi and close to the Jamuna confluence. Tables 3.18 through 3.21 show that average 1989-92 flood conditions were almost identical to those in 1991. Figure 3.36 and Table B.61 therefore show somewhat longer flood durations (blue-green and blue) concentrated in the middle reach, which correlate with more extensive flooding and more low-lying land. Normal monsoon floods last about a month in the middle and lower reaches, but for only 16 days in upper reach attached chars and mainland. Even in a normal monsoon, floodwater may back up in the middle reach as a result of the narrow channel at Hardinge Bridge. In the lower reach (below the bridge), normal flood durations average 20 days, which is almost the same as was reported in the adjoining upper reach of the Padma.

The 1989-92 flood averages are appropriate benchmarks against which to assess the severity of the 1987 and 1988 floods. Tables 3.17 and 3.19 show that in normal conditions 70 percent of study area cultivable land is underwater in the monsoon, but the area of cultivable land flooded at peak level in 1987 was only 6 percent more, and in 1988 the remaining 30 percent of land was flooded (virtually all land flooded). The lack of any overall difference between 1987 and 1989-92 reflects a combination of extensive middle and lower reach flooding in 1987, with unusually little flooding in the upper reach; the latter data may be unreliable or reflect unusual local conditions. In 1987, more land than normal was flooded in the attached chars, while there were smaller increases in the area flooded in the other land types. The middle reach, then, is normally extensively flooded, but in 1988 all Ganges charlands were flooded for more than five weeks.

Flood duration in 1987 increased over normal in the middle and lower reaches for all char land types. Flooding in the middle reach lasted 45 percent longer than normal. In 1988, flood durations increased by about 18 days over normal durations in all land types, and with little difference in the relative increase in duration between reaches (Tables 3.18 and 3.20).

Assuming that agriculture and the charland economy are adjusted to normal monsoon conditions, and that the flooding averages for 1989-92 are that norm, 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 higher color in the scale of yellow through green to blue, then flood extent, flood duration, or both were greater than normal. Homestead land and house plinths are raised and so may not be so badly flooded. Section 3.6.3 reports evidence of flooding to houses.

Figure 3.35 AVERAGE PEAK FLOOD EXTENT 1989-92



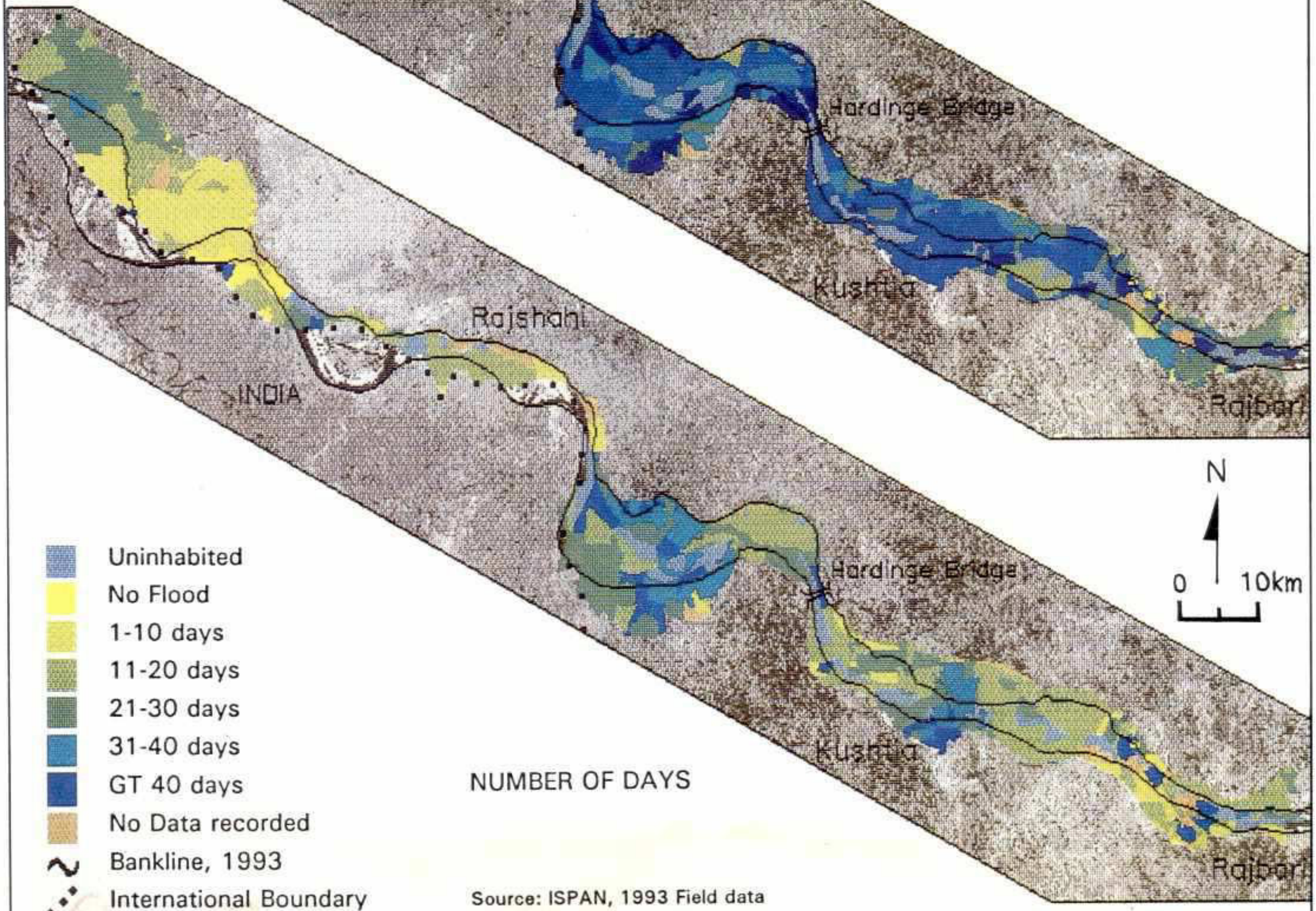


Figure 3.36 AVERAGE PEAK FLOOD DURATION 1989-92

Flood frequency analysis by FAP 25 is available for three BWDB gauging stations on the Ganges: Hardinge Bridge at the boundary of the middle and lower reaches where the Ganges charlands are at their narrowest, and Sengram and Mahendrapur on the south bank of the lower reach. The two lower reach locations are near one another and since more data were published for Sengram in FAP 25 (1992), the data for that site are reproduced here. Unfortunately, there is no available analysis of flood levels and their frequency for the upper reach.

Table 3.22 Return Periods of Ganges Floods

Year	Hardinge Bridge*		Sengram*	
	Level (m)	RP† (years)	Level (m)	RP (years)
1987	14.79	4.0	12.50	21.3
1988	14.87	13.0	12.75	59.1
1989	13.26	na	10.79	1.0
1990	13.98	na	11.55	1.6
1991	14.64	na	12.86	100.0

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

*Gauging stations at the boundary of the middle and lower reaches, and in the lower reach, respectively.

†RP = Return Period; for example, 22.55 indicates a flood that occurs on average about once every 22 years; return periods for 1990 and 1991 are estimated from probability plots in FAP 25 (1992). Return periods for water levels below about 14.80 m cannot be estimated for Hardinge Bridge.

Table 3.22 gives the frequency of annual maximum water levels (flood peaks) estimated by FAP 25. It shows that the 1987 flood was a moderate flood on the Ganges: it had a return period of about 1-in-4 years at Hardinge Bridge[6] and 1-in-21 years in the lower reach. The 1988 flood was severe, ranging from a 1-in-13 year return period to 1-in-60 years; it was worst in the lower reach. Although water levels in 1989 and 1990 were no more than normal monsoon inundation, the level in the lower reach in 1991 was apparently higher than in 1988, coinciding with the 1-in-100 year flood level estimated in FAP 25 (1992). This is not consistent with the flood extent and duration reported in the survey, nor with the return period at Baruria on the upper Padma. The analysis indicates that 70 percent of the Ganges char land normally is flooded in the monsoon, but a 1-in-50 year event floods virtually all land.

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 sheets, bricks, or concrete). In the Ganges study area very few *pucca* houses are constructed of brick or concrete, most were made either entirely of corrugated and galvanized iron (CI sheets) or more commonly had CI sheet 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 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-eight percent of study area houses are reportedly all *kutcha* (Table B.62), but construction varies widely, particularly between reaches. Many fewer houses, for example, have CI sheets in their construction in the middle reach (55 percent of houses are *kutcha*), and there are few (25 percent) *kutcha* houses on attached chars and unprotected mainland in the upper reach (the most stable area). Table 3.23 shows that in the island chars 61 percent of houses are all *kutcha* (these are areas where catkin grass is readily available and the risk of erosion and submergence is high). Figure 3.37 shows mauzas having less than 50 percent of houses using some CI sheet construction (orange and pink) concentrated in the more dynamic and recently accreted char areas. In the more stable unprotected mainland of the upper reach, by comparison, a majority of houses are of CI sheet or have CI roofs (red and dark red). Island char houses, therefore, are less substantial than those of unprotected mainland.

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 in the Ganges charlands there were very few households reported to be taking shelter in 1993 either on other people's land or on public land. The few mauzas with such people were concentrated in Shibganj near the Indian border in the upper reach, near Rajshahi, and along the banklines in the lower reach. In these few mauzas, more than 10 percent of households are sheltered.

The RRA found that displaced people move to nearby mainland areas and nearby towns (which lie outside the charlands). Unlike the other main rivers there appear to be few people living as *uthuli* on other people's land in the Ganges charlands. This may be because there has been relatively less erosion and more accretion since 1984 (Chapter 2). The RRA also found that there had been organized movements of settlers into the chars under the patronage of large landlords. In addition, the Ganges charlands are very confined, so people are more likely to have moved beyond the embankments into the mainland.

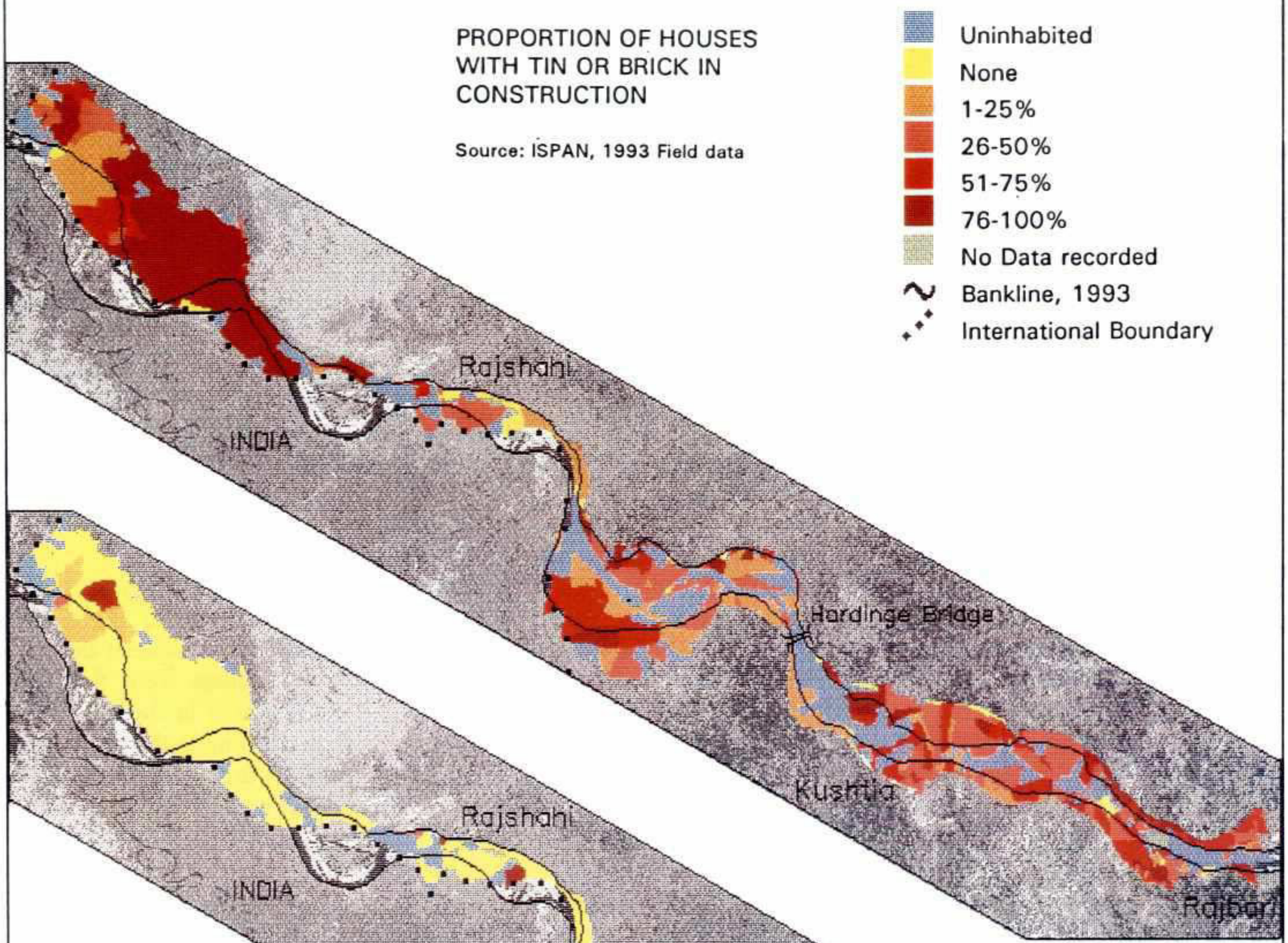
While houses are not usually moved in floods, people and possessions often are moved to higher places when flooding is severe. To do this effectively sufficient warning is needed. The RRAs found that in past floods people most often reacted according to observations of rising flood water. In the Ganges charlands informants also said that they got advance warning by listening to

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

Char Type	Percentage *Kutcha*
Island Char	61
Attached Char	32
Unprotected Mainland	38
Total	39

Source: Table B.62

Figure 3.37 HOUSE CONSTRUCTION



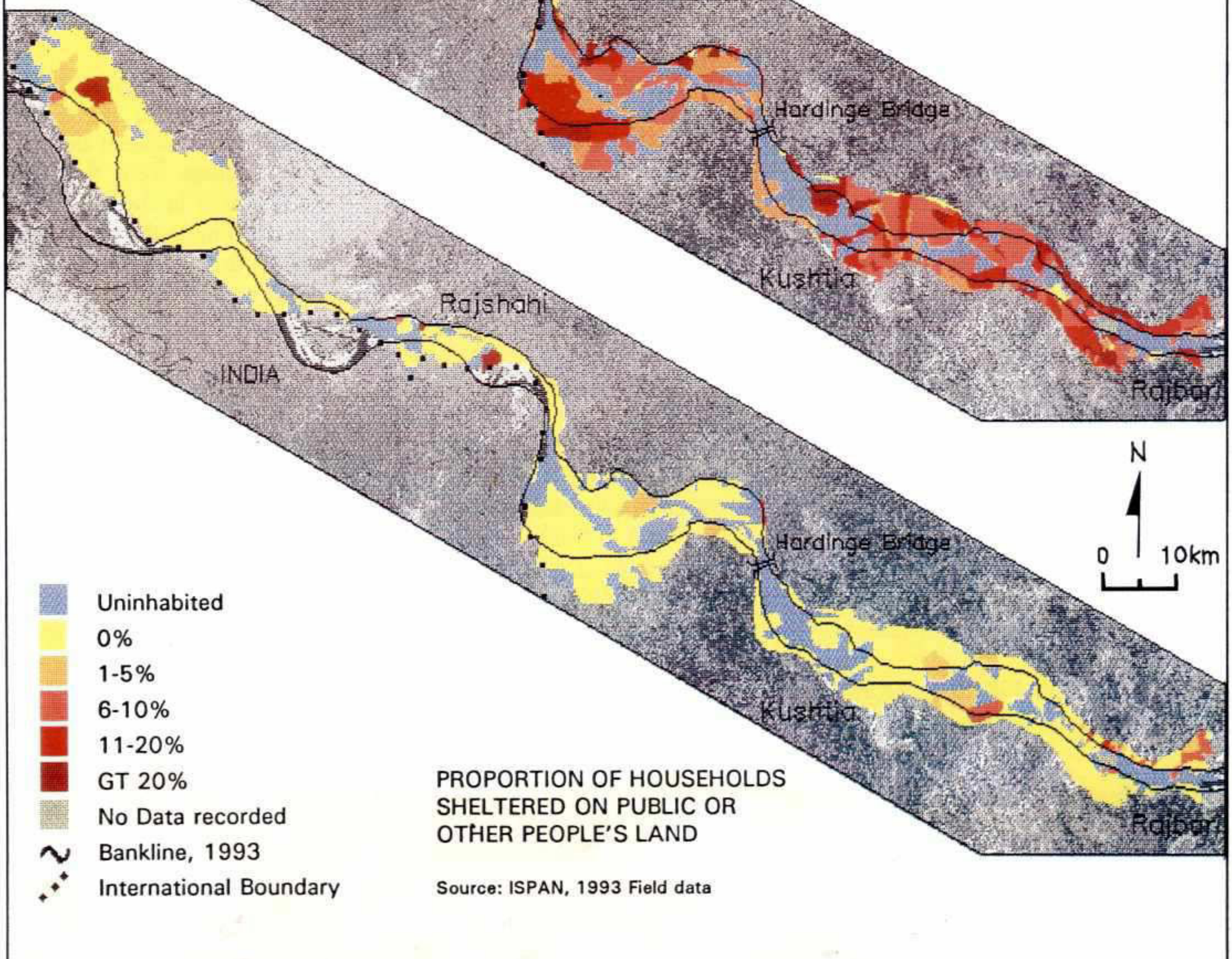


Figure 3.38 HOUSEHOLDS SHELTERED IN MAUZA

Table 3.24 Percentage of Houses Destroyed by Flood

Reach	1987	1988	1989-92*
Upper	4	27	1
Middle	6	25	0
Lower	8	27	0
Total	6	27	1

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

flood reports on Indian radio for upstream areas. They may therefore have been better prepared than other char areas. Access to radios is reportedly good—an average of about one radio to seven households in all charland types (Table B.63)—but there appear to be many fewer radios in the middle reach (average of 22 households per radio with very few in the attached chars). This area, worst affected by floods, might benefit most from improved warning services through the local administration. In the upper and lower reaches people apparently can get some advance warning of floods from the radio, 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), as well as the percentage of houses destroyed in each year from 1987 to 1992. Part of a "destroyed" house in many cases may have been salvaged. In Tables B.64 to B.69, reach and char type percentages have been calculated by weighting mauza percentages by the number of households in the mauza in 1993.

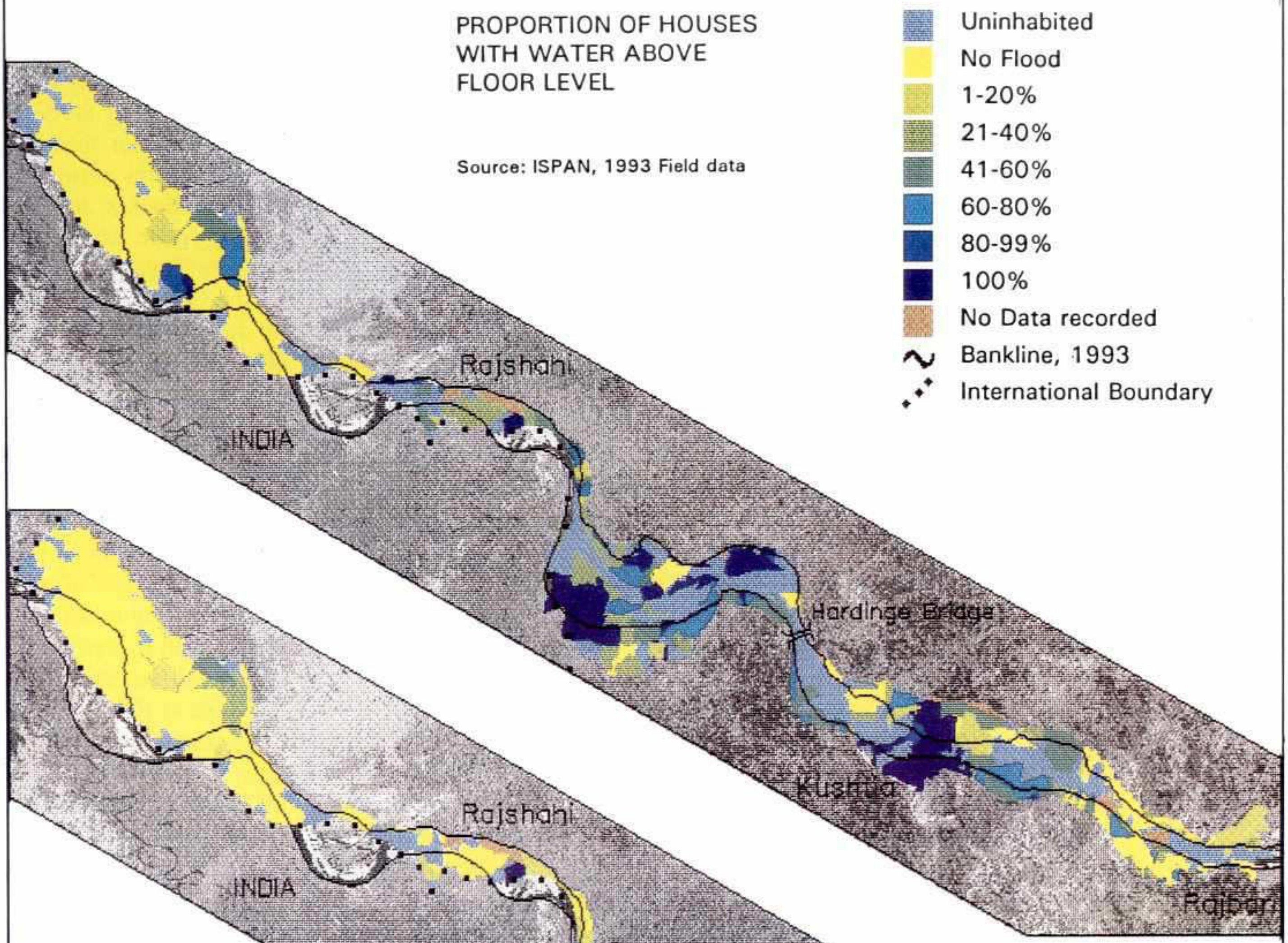
In 1987, 34 percent of all houses in the Ganges charlands were reportedly flooded. Virtually no houses were flooded in the upper reach, but Tables 3.24 and B.64 show that the situation was much worse than average in the middle reach, where 63 percent of houses flooded. Figure 3.39 indicates that in the upper reach some flooding of houses occurred in the Mahananda River floodplain near its confluence with the Ganges. Other than houses within the Ganges channel, however, virtually none were flooded by the Ganges. A high percentage of houses were flooded within a limited area: from the middle reach to the upper part of the lower reach near Kushtia (in the chars just downstream of the Gorai offtake). This differs somewhat from the flood extent data (Figure 3.31), which showed extensive flooding in most of the charlands except for the farthest upstream area, but is closely matched with the areas that reported longer duration flooding in 1987 (Figure 3.32). It appears, then, that flooding was more severe in the middle reach, yet the return period estimate for the 1987 flood level at Hardinge Bridge is lower than that for the lower reach.

Very few houses were destroyed in the 1987 floods. Figure 3.40 shows that the 6 percent destroyed (Table B.65) were spread through the mauzas where more houses were flooded, but they were not concentrated in the middle reach. The relatively deep flooding in this reach inundated a majority of its houses; 7 percent of houses were flooded above roof level (compared with virtually none in the other reaches), although few were destroyed.

In 1988, in most mauzas all the houses were flooded (dark blue in Figure 3.41, averages near 100 percent in Table B.66). The exceptions are Nawabganj Thana and the chars of Godagari Thana, both in the upper reach, where 37 percent of houses were reported to have flooded. Table B.67 and Figure 3.41 show a trend in the percentage of houses flooded from 71 percent in the upper reach to 96 percent in the lower. There was no difference between land types. These differences may reflect the relatively more confined charland area farther downstream, and the influence of Jamuna water levels close to the confluence.

Table 3.25 shows no equivalent trend in the percentage of houses destroyed, an almost uniform 27 percent through the three reaches. Figure

Figure 3.39 HOUSES FLOODED 1987



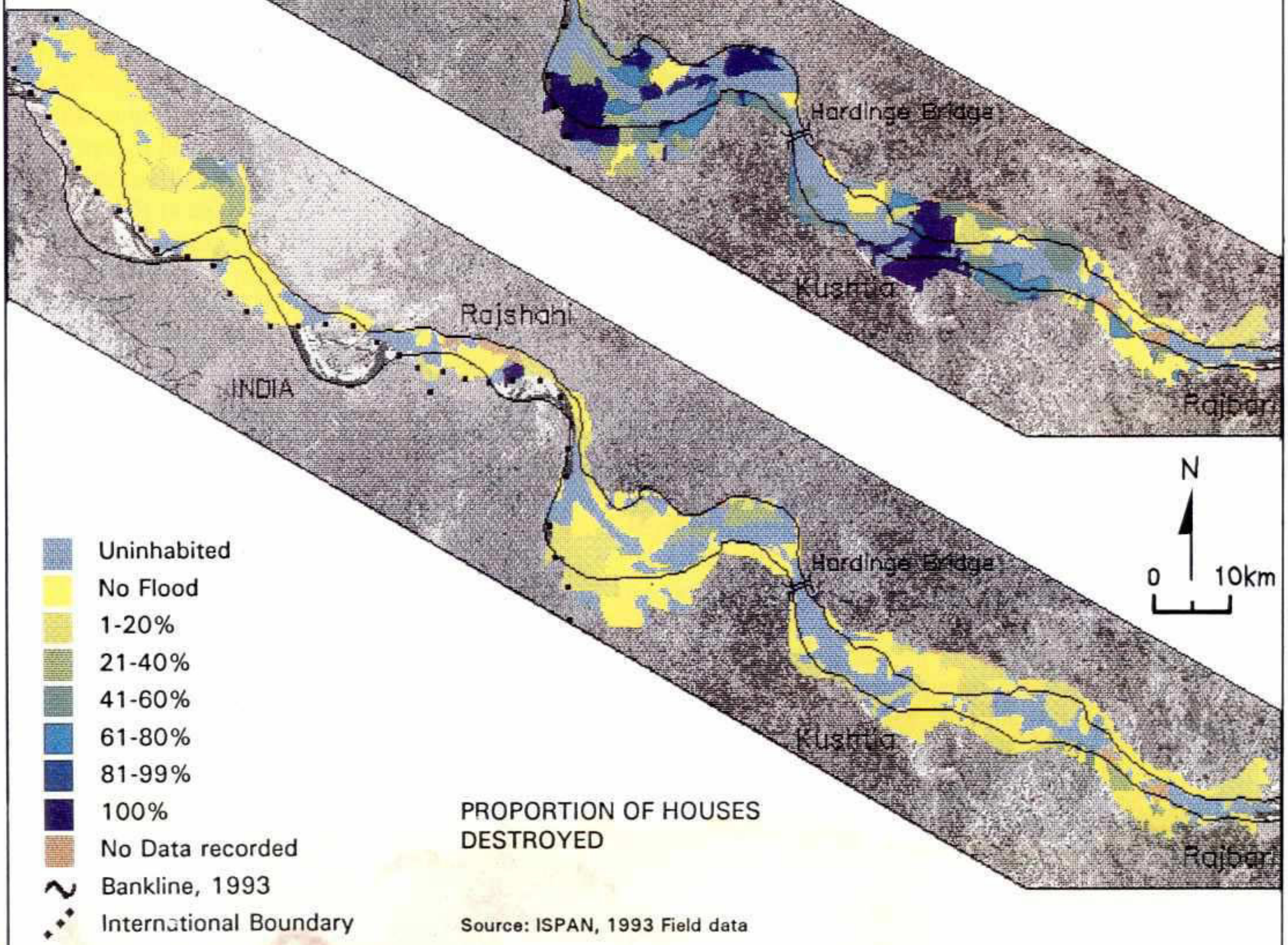


Figure 3.40 HOUSES DESTROYED BY FLOOD 1987

Table 3.25 Percentage of Houses Flooded by Year

Reach	1987	1988	1989-92*
Upper	15	71	4
Middle	63	86	1
Lower	39	96	2
Total	34	86	3

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

3.42 reveals that most mauzas had a few houses destroyed in 1988 (green and blue-green shades), but slightly higher numbers were affected (blue) near Nawabganj town, in the islands of the middle reach, and on the south bank of the lower reach. Island chars did slightly worse than others; 33 percent of their houses were destroyed. This is a lower level of housing destruction than occurred in the Padma. Table 3.26 shows that the middle reach was more seriously affected; 20 percent of houses flooded above the roof, compared with few in the other reaches. The island chars of the middle reach, therefore, were most severely affected, although most of the houses not flooded to the roof appear to have been relatively well situated since they were not destroyed despite being of mostly *kutcha* construction.

On average during the four years 1989-92 there has been virtually no flooding of homesteads in the Ganges charlands. Figures 3.43 and 3.44 reveal those mauzas where a low percentage of houses were reported flooded and destroyed. These are largely restricted to the Shibganj-Nawabganj border in the upper reach, and to island and attached chars along the main river channel in the middle and lower reaches. Only a minority of charland homesteads are not adjusted to normal monsoon flood levels. People in the island chars of the upper and middle reaches also appear to have adjusted their houses to the normal range of extensive floods shown in Figure 3.37.

Compared with the 1989-92 average, in the 1987 flood about 11 times more charland houses were flooded than normal, and in 1988 the majority of houses (86 percent) were flooded compared with the norm of 3 percent. In terms of housing flooding and damage, then, the range between normal and severe floods in the Ganges is very great, much greater than in the Meghna. It is very rare in normal monsoon conditions for houses to be destroyed by flooding, none were reported to be flooded to roof level. The surveys revealed that in the Ganges charlands 4.5 times more houses were destroyed in 1988 than in 1987, and the most affected areas in both years were in the upper and middle reaches.

The percentage of houses destroyed by flooding clearly reflects the flood return period, but it appears that in a moderate flood the middle reach is much more badly affected. This may be due to a combination of a high proportion of people living on low-lying and highly vulnerable island chars (28 percent compared with 6 percent in the other two reaches) and confinement of flood flows by the Hardinge Bridge at the downstream boundary of the reach. By comparison, houses in the whole of the Ganges charlands were badly affected in a severe flood (1988), although flood depths inside houses in the middle reach were greater than elsewhere.

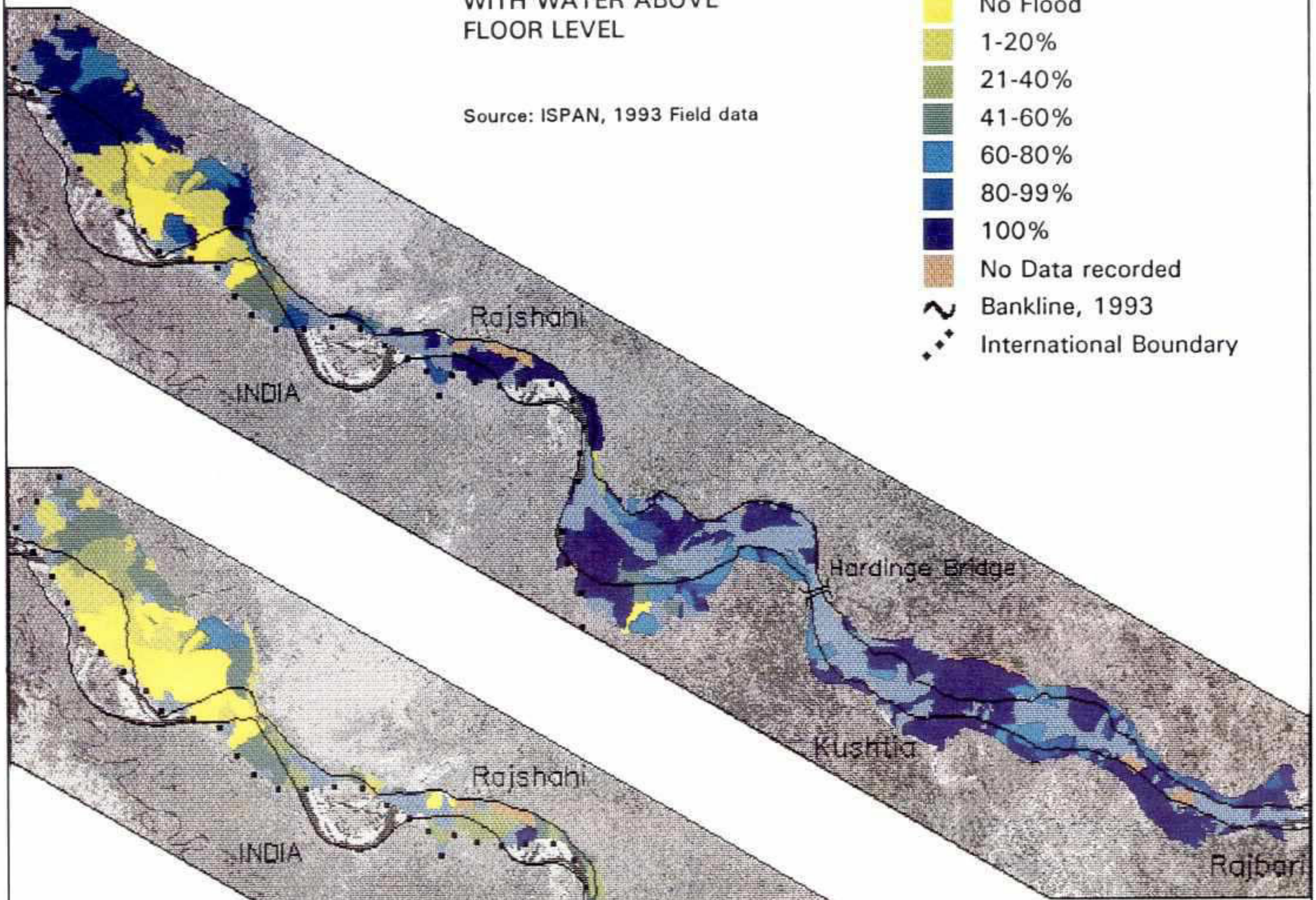
The gauging records at Hardinge Bridge indicate very little difference in peak water level between a 1-in-2 year event and the 1987 and 1988 flood

Table 3.26 Percentage of Houses Destroyed by Char Type

Char Type	1987	1988	1989-92*
Island Char	8	33	.7
Attached Char	4	23	.3
Unprotected Mainland	6	27	.3
Total	6	27	.4

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

Figure 3.41 HOUSES FLOODED 1988



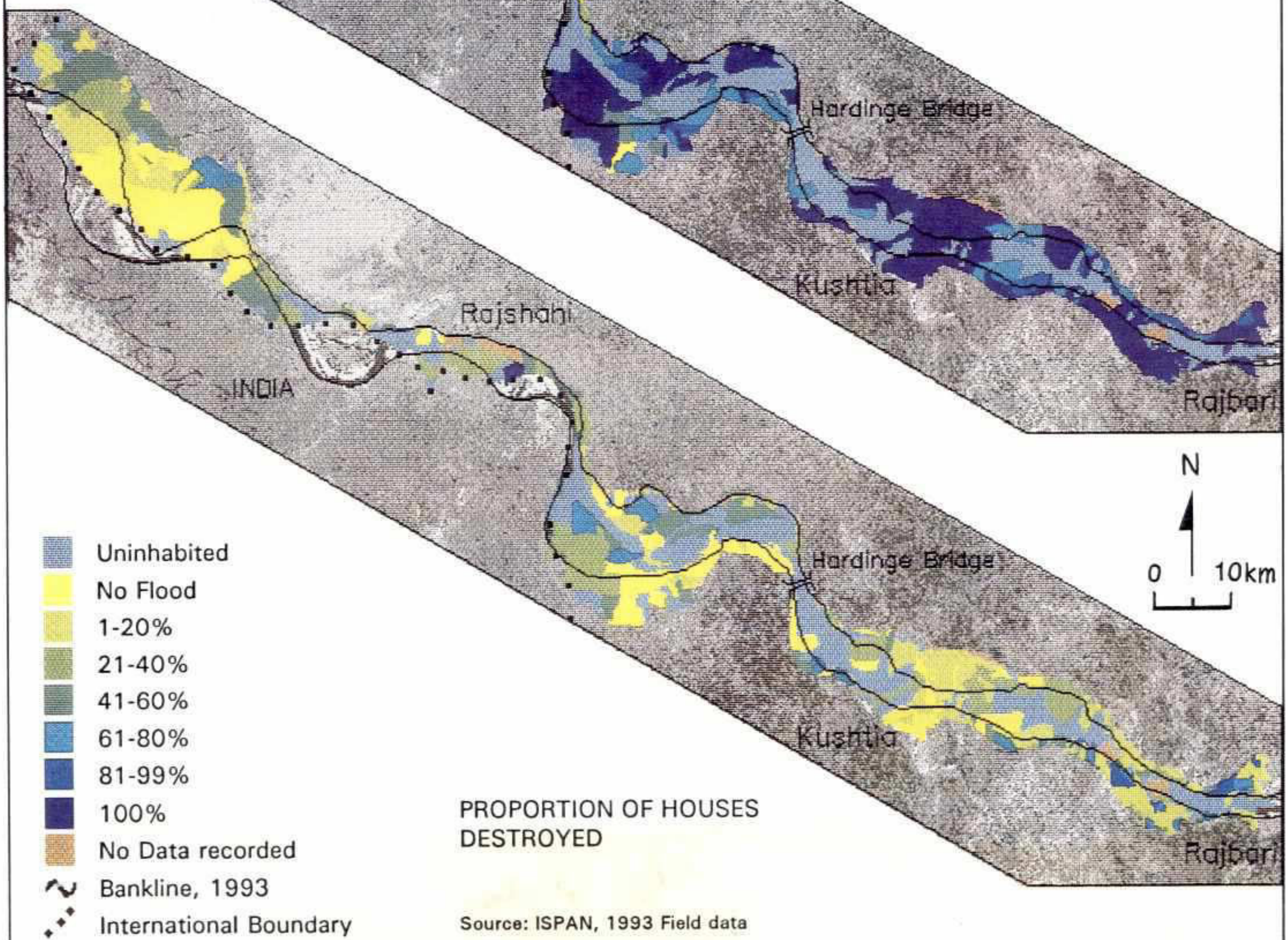


Figure 3.42 HOUSES DESTROYED BY FLOOD 1988

levels. This is inconsistent with the reported differences in flood severity in the middle reach. Unfortunately, there are no gauging stations with data analyzed by FAP 25 in the upper reach nor in the upper part of the middle reach. Water levels at Sengram in the lower reach also imply that there should have been little difference in housing damage between 1987, 1988, and 1991 as the difference in peak water level in these three years is reported to have been only 36 cm. The inventory reports of housing damage in this reach differ very greatly between these three years. In the Meghna and Padma charlands the estimated percentages of houses flooded and destroyed from the inventory were generally in agreement with recorded peak water levels and with the FAP 25 frequency analysis. As this is not the case in the Ganges charlands, more detailed information—on land and house floor levels, on losses experienced in 1987-92, and on the water levels recorded at specific sites—is needed for all three reaches of the Ganges charlands.

3.6.4 Flood Risk

The severity of flood impact seems highest in the middle reach of the river. This is also the area that had more deaths related to flooding in 1988 and poorer housing construction. This indicates a priority need for flood proofing interventions in that reach under the present river regime.

Much of the Ganges charlands are already contained within embankments. FAP 25 (1993) modelled the possible changes in peak water levels both with consolidation and improvement of the right (south) bank embankments and with possible backwater effects from embankments downstream on the Padma and Jamuna. Although embankments along the Mahananda were listed in the possible program for the northwest region, they are only long-term proposals (FAP 2, 1992) and were not modelled.

The relevant scenarios in FAP 25 (1993) are scenarios 4, 5, and 6. There is virtually no difference for the Ganges in predicted changes in water level between these scenarios, which indicate that embankments on the Padma would not affect the Ganges charlands. Scenario 5 represents improvements to the Jamuna embankments, the Jamuna Bridge, plus full flood control embankments along the Ganges and Padma. Table 3.27 shows that the predicted increment in peak water level is virtually the same for all three years modelled, 1986 (a normal year), 1987, and 1988. It should be remembered that the model predictions relate to the same flood levels discussed above, which were found to be at variance with the reported flood impacts in the inventory. An 18 cm increase in water level in the lower reach is about 50 percent of the difference between normal (1986) and 1988 flood levels. This latter increase in peak water level was associated with 27 percent of houses in the reach being destroyed. Hence, only in the lower reach is it likely that embankment projects in Bangladesh would result in any raising of flood levels in the Ganges charlands. The increase in water level would not be large, but it is unclear what its impacts might be.

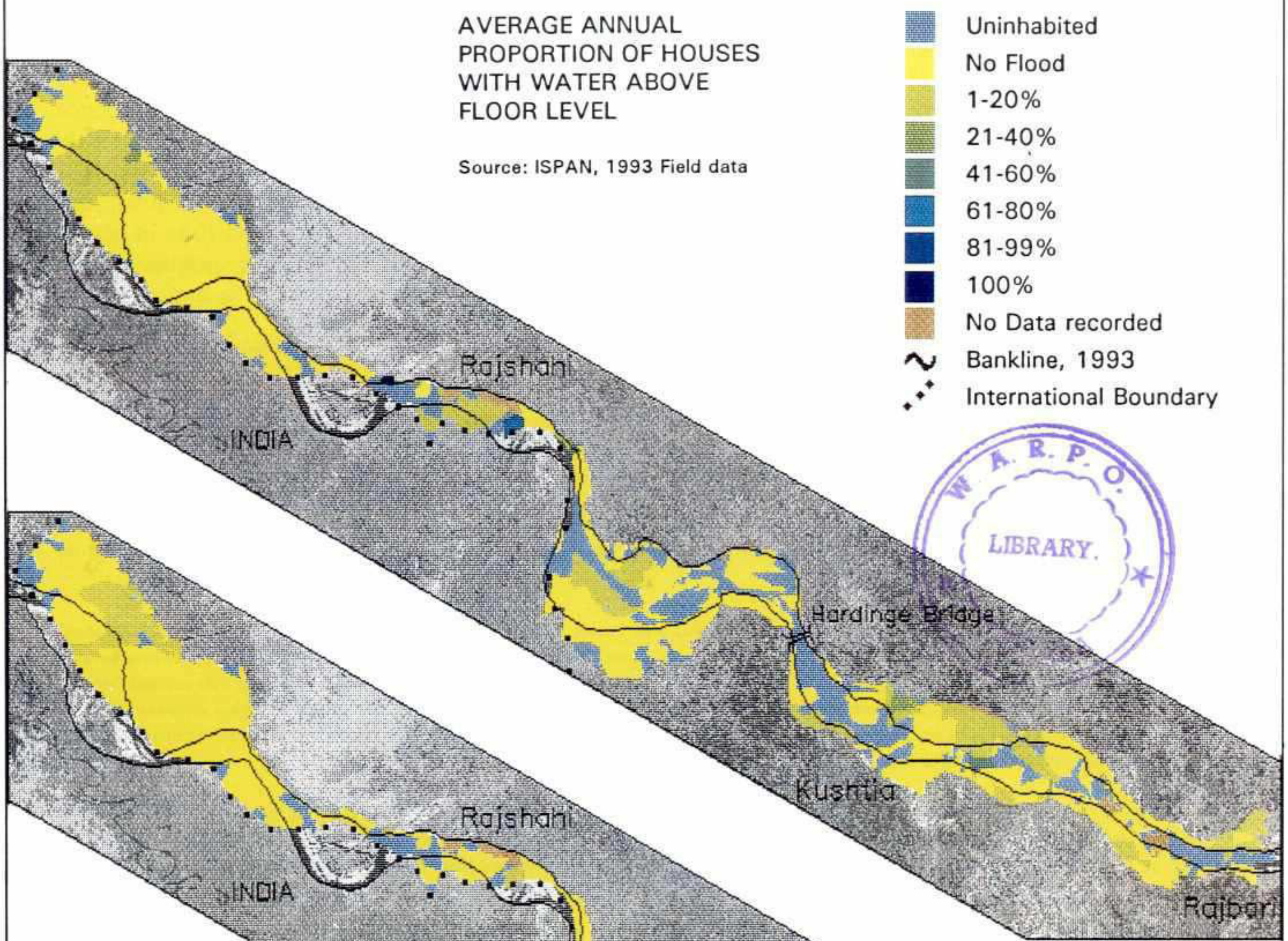
Additional data, preferably mapped outputs from a rechecked hydraulic model using a digital eleva-

Table 3.27 **Changes in Peak Water Levels with Embankment Scenarios**

Year	Scenario	Hardinge Bridge	Mahendrapur
1986	Actual (m)	14.11	np*
	5 (+)	.04	.18
1987	Actual (m)	14.79	np*
	5 (+)	.06	.17
1988	Actual (m)	14.87	np*
	5 (+)	.06	.18

Source: FAP 25 (1992), FAP 25 (1993)
*Not published in FAP 25 (1992)
Note: Scenario 5 = essentially full embankments along all main rivers. See FAP 25 (1993) for full details.

Figure 3.43 HOUSES FLOODED 1989-92



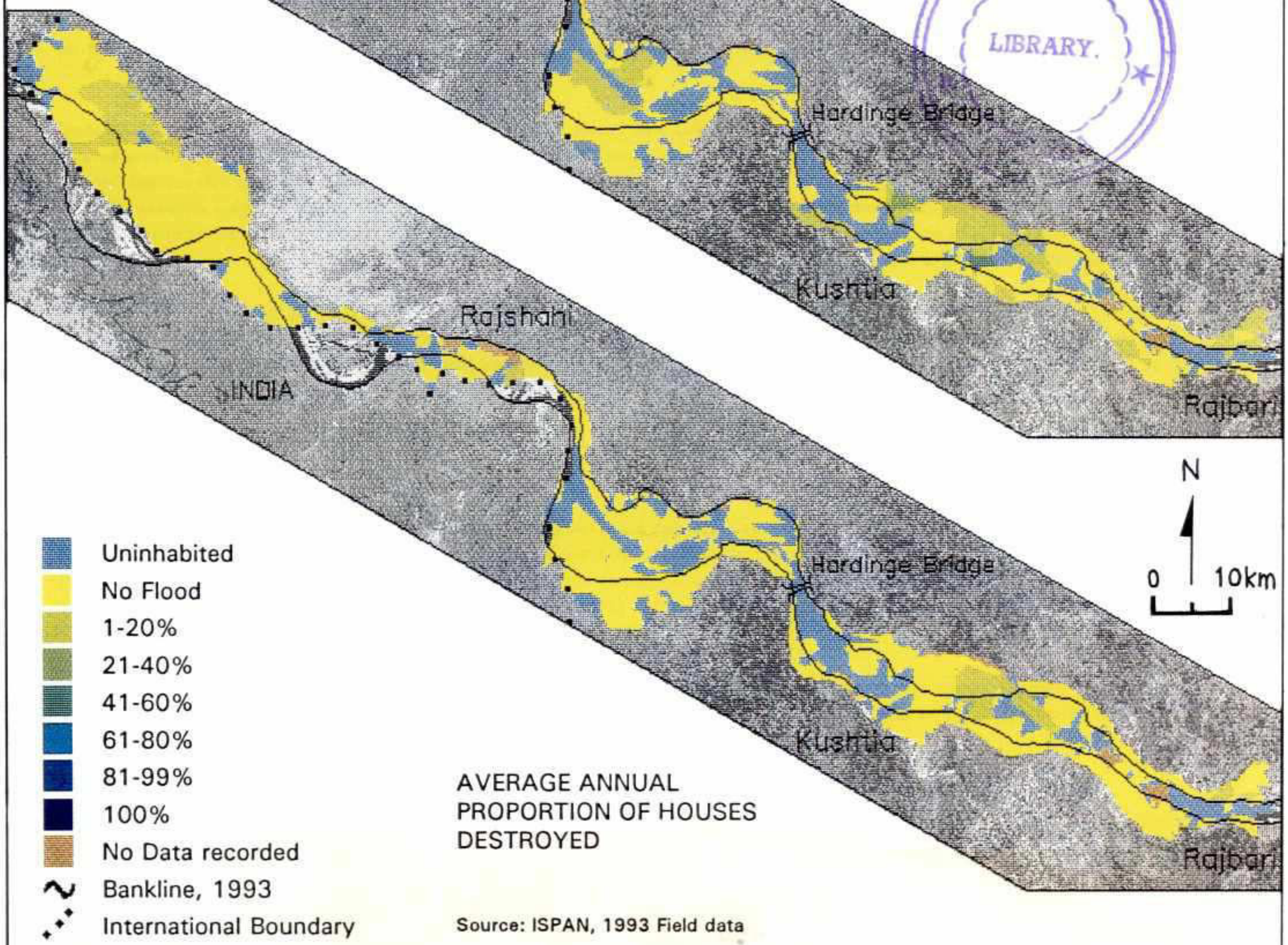


Figure 3.44 HOUSES DESTROYED BY FLOOD 1989-92

tion model (DEM) and linked to accurate ground and property level data for sample areas, would be needed to make a more complete assessment. These data could be used to more accurately model flood impacts, as well as the potential benefits of flood proofing measures. Failing this, a series of satellite images on a rising and falling flood would be useful, or images of flood peaks in successive years. These should concentrate on the middle reach, which has suffered most in past floods, and on the lower reach, where there is more risk of increased water levels. 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 middle reach is a priority for measures to reduce flood impacts. This area also appears to be poorly served by infrastructure. More detailed study of the perceived needs of char people, flood impacts, local topography, and flood risks in particular reaches is needed before appropriate local flood proofing interventions can be designed.

NOTES

1. Population data from the 1991 census are not yet published for the whole Ganges area and would require apportioning. 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. 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.

3. These frequencies, or return periods, of flood damages are indicative since they are based only on the period 1988-92. They simply state, for example, that in the upper reach, aus was on average reported to have been damaged by floods twice in the past five years. These figures, however, indicate recent flood experience. Damages therefore have been frequent given that only 1988 was the only severe flood year among the five years considered.

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

5. Comparison of Figures 3.29 and 3.30 also shows that a few more mauzas were uninhabited (blue) in 1988 than in 1993, implying some accretion and resettlement since 1988. Some mauzas may have been inhabited at that time, but no one was available in 1993 to recall flood experience in 1988. In general, however, key informants seemed to know very well when mauzas had been submerged and when they had been resettled. 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.

6. The return period estimate at the reach boundary appears to be low compared with the flood impact. FAP 25 (1992) reported problems in estimating return periods for that site.

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 Ganges that is independent of mauza boundaries. The inventory population and resources data is not easily divisible below the mauza level—the primary data collection unit. Despite this limitation on the integration of the two data sets, 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 Ganges Charland Study area is estimated to have been about 691,000 (Section 3.2); compared with 653,000 in 1981. This represents an increase of only 6 percent. The 1993 population density of the area was 443 people per km² (total area, including water), and 673 people per km² of vegetated or cultivated land. By comparison, the national population density in the 1991 census was 763 people per km² (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. Where the land is reported to be 10 years old or less, population densities are very low (Table 4.1). For example, only 1,927 people were reported living in 82 mauzas where the land accreted in the previous five years. By comparison, land that accreted between 10 and 70 years previously averaged just over 400 people per

Table 4.1 Population Density in 1993 by Age of Land*

Land Age (years)	Aggregate people per km²	Mauza average people per km²
1-5	37	87
6-10	209	335
11-20	412	593
21-30	438	525
31-70	439	782
71+	983	2,830
All land†	679	1,612

Source: Inventory survey

*Excludes mauzas which were uninhabited but cultivated.

†Includes mauzas for which age of land is not known.

km^2 of vegetated/cultivated land, compared with 983 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.

These population densities are much lower than in the Meghna and Padma charlands. The population living on land between 11 and 70 years old is particularly sparse in relation to the other rivers, implying that old land in the Ganges charlands is less productive than elsewhere. On the oldest land type, however, population density is closer to that found in the other rivers. This category consists of established mainland, and it seems to have a much higher carrying capacity in the Ganges than land accreted 30 or more years ago. Population density appears to be more closely related with land age than with land type in the Ganges charlands.[1]

Comparison with Figure 2.10 and Section 3.2 reveals that most of the Ganges charlands have accreted within living memory. The oldest land in the area, the mainland closest to the embankments, is probably more densely populated because of higher land productivity. In char areas in general, as accreted land matures the organic material in its soil may increase, enhancing agricultural productivity. In the Ganges this is less common, and many of its chars have very sandy soil. As a result, low productivity may persist and even on relatively old chars, population density is low. Even if equivalent areas of charland are accreted to compensate for 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. No lives were reported lost due to erosion.

The total study area is 156,800 ha, of which in March 1993 there were 102,670 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.

Compared with the other rivers surveyed, very little land was reported to have been eroded in the Ganges charlands (Tables B.69 to B.72). In 1987, only 24 ha were reported to have eroded, yet this was a moderate flood year (Section 3.6.2). In 1988, 325 ha were eroded, virtually all of it in the upper reach, and in 1989-92, 999 ha were eroded—an average of 250 ha per year. In all cases, the inventory found that the greatest impact was in the upper reach, yet the satellite image analysis in Chapter 2 showed that 53 percent of bank erosion during the 1984-93 period took place in the middle and lower reaches. While most of this erosion may have taken place before 1987, it seems unlikely. The inventory appears to be unreliable on this question, but part of the difference may arise where land, rather than eroding, was converted from mainland to char when branch channels developed.[2]

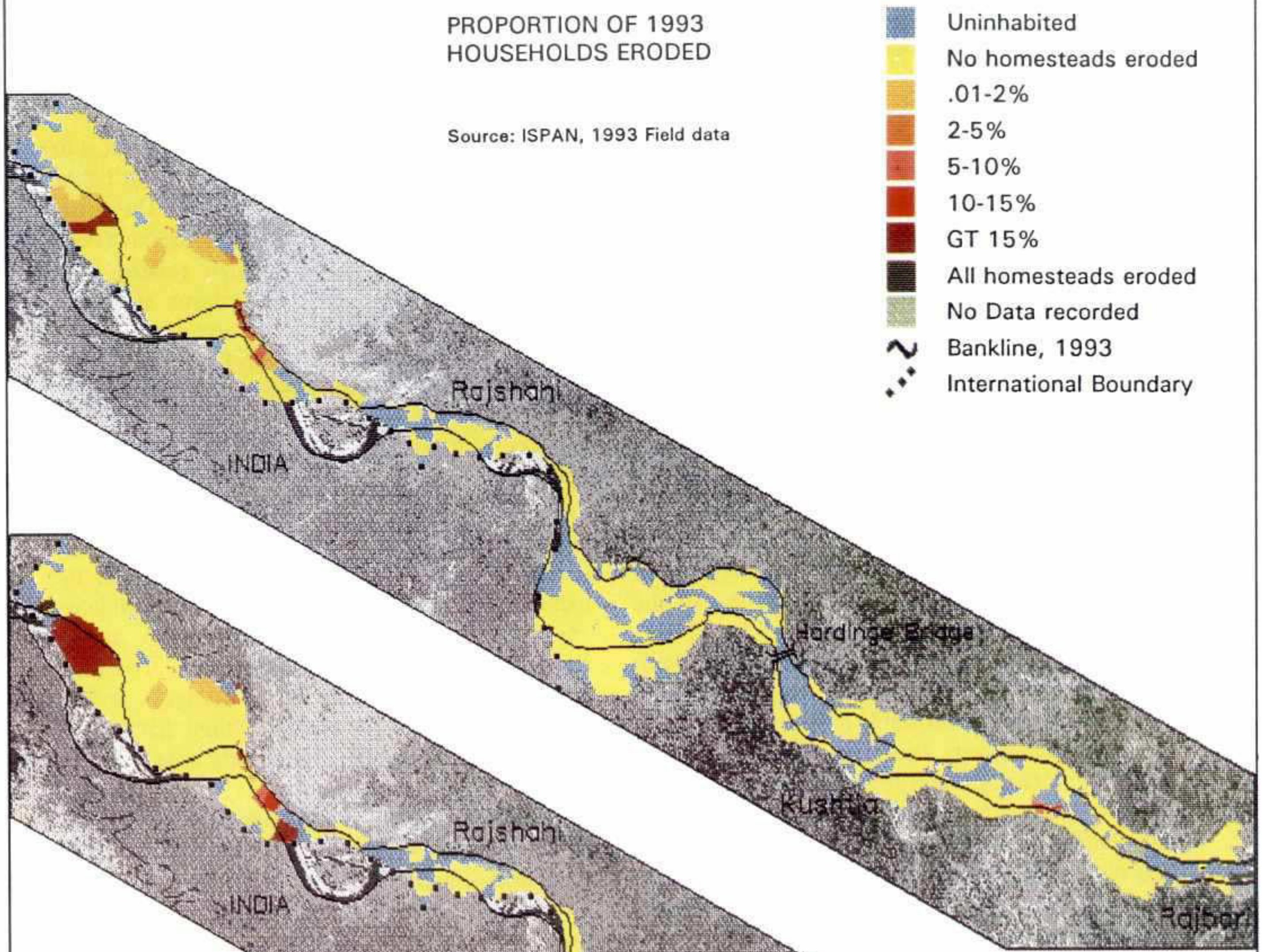
The same problems arise with the estimates of homestead loss to erosion. Figure 4.1 shows the distribution of mauzas reporting erosion of homesteads in the peak flood year of 1988, when a total of 304 were said to have eroded (Table 4.2). The

Table 4.2 Percentage of Eroded Homesteads in Each Reach

Reach	1987	1988	1989-92
Upper	70	92	95.3
Middle	0	0	0.5
Lower	30	8	4.2
Total (no.)	40	304	1,174

Source: Tables B.73 to B.75

Figure 4.1 HOMESTEADS ERODED 1988



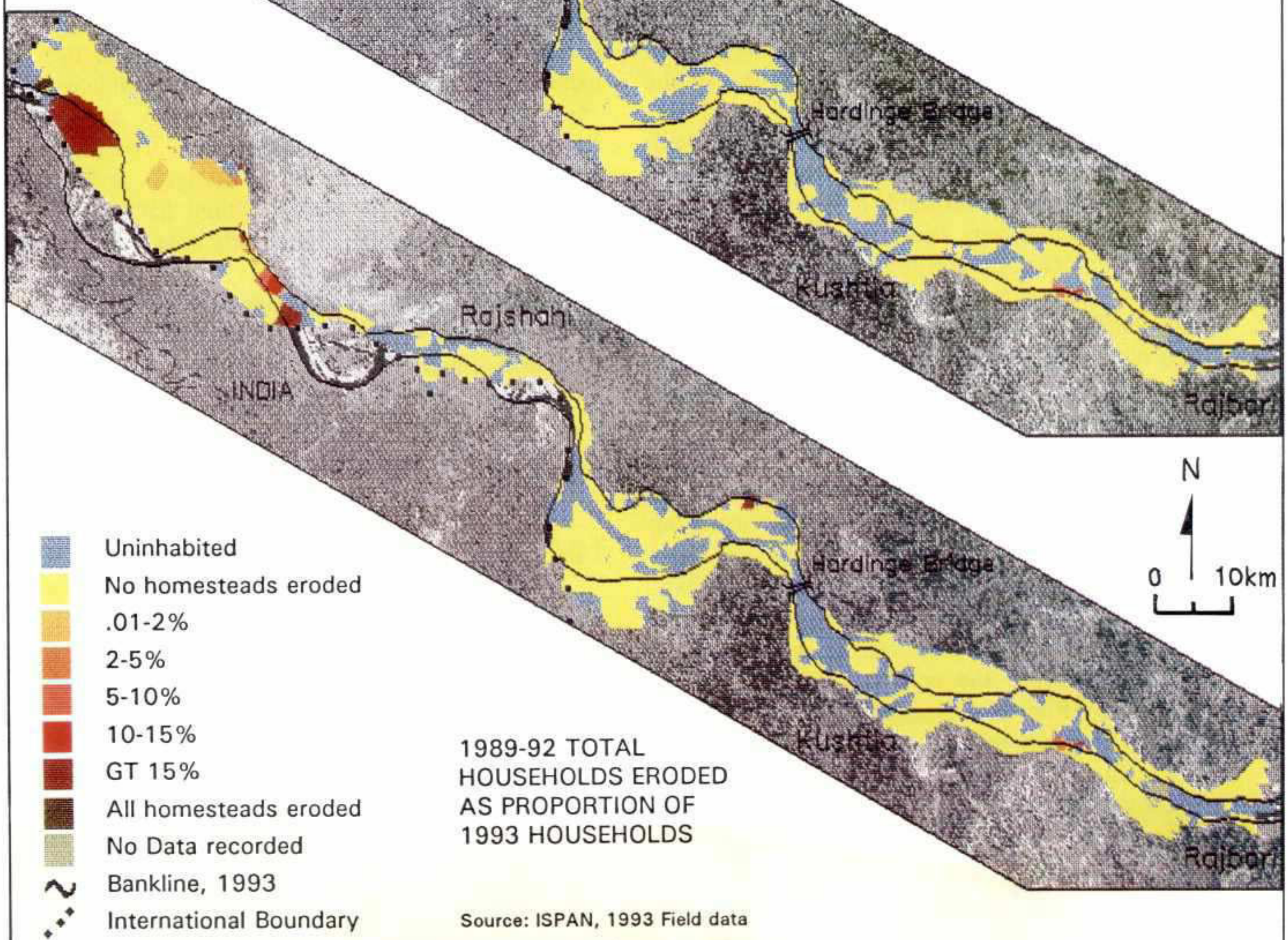


Figure 4.2 HOMESTEADS ERODED 1989-92

number of homesteads reported affected is low and concentrated almost entirely in unprotected mainland in the upper reach at the outer bends of meanders. This pattern continued at almost the same rate of loss between 1989 and 1992. Figure 4.2 shows the areas worst affected were in Shibganj and Godagari thanas. Since 1988, more homesteads in island char mauzas were affected (35 percent of those eroded), and some erosion was reported in the lower reach. The upper reach meanders, however, appear to have caused most homestead losses.

Two factors may explain loss reports that were lower than estimates of erosion from the image analysis. One is that char erosion may have been unrecorded; where all homesteads were lost and the affected people moved away, no informants were left to report the loss. The other is that the Chapter 2 erosion is based on banklines interpreted from satellite images. Since a large part of the within-bank area is above water in the dry season, bankline movements may not be associated with real loss of homesteads but, rather, conversion of more stable land to less stable (but usable) attached charland. Moreover, these changes may not be related to loss of homesteads, since in most of the Ganges charlands there are low populations up to mainland near the bounding embankments, hence the results from the inventory are close to those derived later in this chapter from the image analysis and population estimates.

The inventory reports indicate that in the Ganges area a total of 1,518 homesteads eroded (including both bank and char erosion) between 1987 and 1992 and their households were forced to move. Of these, 29 percent were in island char mauzas and may have been displaced by within-channel erosion. Because the number of homesteads is unknown, Figures 4.1 and 4.2 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 about 6 percent of study area households were displaced by erosion during the 1987-92 period.

4.4 Changes in Population and Mainland 1984-93

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. Figure 4.3 shows the areas eroded and accreted between the 1984 and 1993 dry season satellite images overlaid on the mauza boundaries.

Mauzas entirely within the channel in 1984 and 1993, and mauzas entirely on the mainland (not touching the bankline) in 1984 and 1993, were identified separately to check population trends in the two charland types that were unaffected by bank erosion. Mauzas 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 4.3 shows that, in the Ganges study area, 14 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 relatively large area of land accreted in the same period (which

Table 4.3 Summary of Study Area

	Area (ha)
Mainland, 1984	96,696
Channel, 1984	66,328
Total, 1984	157,014
Mainland Eroded 1984-93	13,781
As Percentage of 1984 Mainland Area	14.3

Source: FAP 19 satellite image analysis

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Bankline Changes 1984-93 With Mauza Boundaries

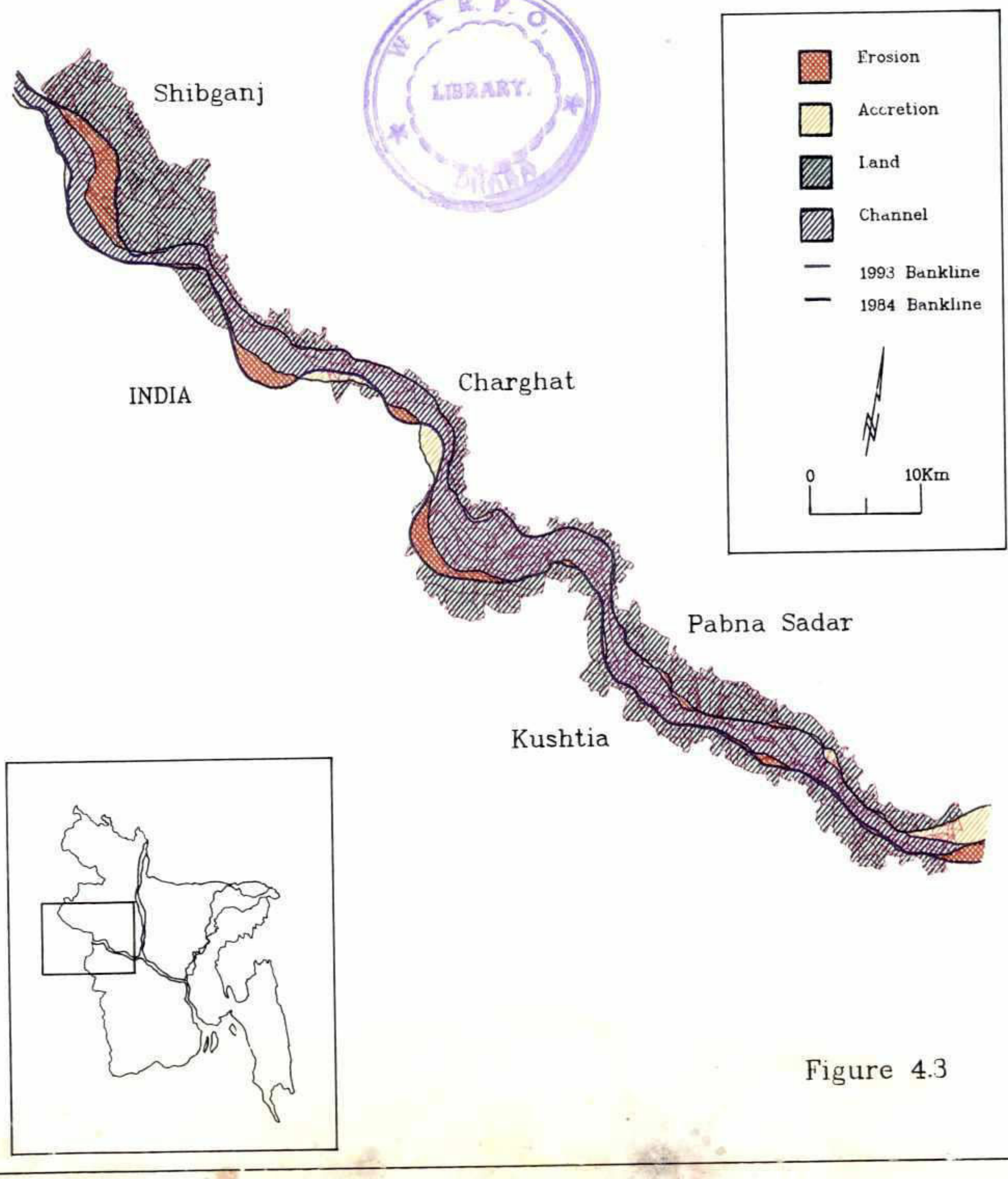

Figure 4.3

amounts to 37 percent of the net eroded area). The net area lost was 8,677 ha. Bank erosion was concentrated in the upper and middle reaches (47 and 35 percent of the total lost, respectively). The loss in the upper reach is consistent with the inventory reports, but there were virtually no reports of erosion in the middle and lower reaches. Accretion was concentrated in the lower reach (66 percent), particularly at the Ganges-Jamuna confluence on the north bank. There was net accretion of 773 ha in the lower reach, the one exception to the trend for channel widening found among the reaches of all four rivers investigated.

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

Reach	Eroded (ha)		Accreted (ha)	
	West	East	West	East
Upper	2,453	3,976	876	231
Middle	3,193	1,574	83	556
Lower	1,396	1,189	666	2,692
Total	7,042	6,739	1,625	3,479

Source: FAP 19 satellite image analysis

It should be remembered that this analysis ignores many morphological changes that occurred during the period. For example, some areas may have eroded and accreted within the period of analysis.

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 Ganges in 1981-84, and population density is very 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 had the bankline changed significantly between the 1981 census and the 1984 image.[3]

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 55,000 people—about 8 percent of the study area population in 1981, which is slightly higher than the inventory-derived estimate in Section 4.3.

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.

Table 4.5 Population by Land Status, 1981-93

Population in:	1981		1993	
	Number	%	Number	%
Unprotected Area	653,651	100	691,428	100
Within Banklines	128,645	20	143,014	21
Eroded Area 1984-93	55,005	8	0	

Source: 1981 BBS census and 1993 FAP 16 inventory

If it is assumed 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 (a conservative assumption because of uncertainty over the sequence of erosion events and

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

Reach	Percent of 1984 Population		Population Density in 1984 (per km²)	
	West	East	West	East
Upper	22	53	315	323
Middle	61	23	663	353
Lower	17	24	431	502
Total	34,900	24,394	496	362

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

population shifts), then some 58,700 people were probably displaced by bank erosion.

Table 4.6 shows the 1984 population estimated to have been affected by erosion between 1984 and 1993. Population density on this land in 1981 averaged 399 people per km² (based on Table 4.6), which is only 66 percent of the density in 1981 for mainland unaffected by erosion during 1984-93 (606 people per km²). The areas eroded, therefore, had relatively low population densities, and the satellite images (Figures 2.1 and 2.2) indicate that most of the eroded land was relatively new attached charland near the international border in Shibganj and Nawabganj thanas. Because the land was young, its population was low in comparison with areas unaffected by erosion, such as mainland that remained outside the bankline in this reach.

More people were estimated to have been displaced by erosion of the south bank because of the somewhat higher population in the area of eroded middle reach mainland near the international border. Table 4.6 shows that this was the only eroded area with the same population density as in unaffected mainland.

Accretion resulted in a fairly large compensating land gain of 5,104 ha. Much of this land was on the north bank near the Jamuna confluence. Assuming that this area had the same population density as the mauzas as a whole, this land had about 550 people per km² (100 people fewer than the 1993 density on mainland unaffected by erosion or accretion). However, the 1993 population density on south bank accreted land appears to be much lower (394 people per km²) than on north bank accreted land (556 people per km²).

About 25,750 people were estimated in 1993 to be living on land that had accreted since 1984. The net effect of bank erosion and accretion, then, was that some 58,700 people present in 1984 were displaced by erosion by 1993 (ignoring population growth and movements not related to erosion). Just under half of that number of people had been accommodated on land that accreted in the same period. Morphological changes, therefore, have had relatively little impact on population distribution in the Ganges charlands.

As Chapter 2 explains, the river channel in the upper and middle reaches was widening during the period studied, while it narrowed in part of the lower reach. Therefore, no new land was created near the areas where people were displaced by erosion. In the upper reach, about 20,600 people were displaced, and in the middle reach, about 26,700 people were forced to move. In the same reaches in 1993, newly accreted land supports only 7,300 and 4,200 people, respectively. In the lower reach, the populations on land lost and land gained balance out—in 1993, only slightly more people are living on accreted land than were living on the eroded land in 1984.

While it has not been possible to relate population changes with in-channel morphology, the population trend in mauzas remaining completely in-channel over the period has been assessed. Table 4.7 shows a decrease in total population in these mauzas. In the upper reach, there are no mauzas completely within the banklines.

The population within the banklines of the middle reach increased by 22 percent between 1981 and

Table 4.7 Population Growth in Within-Bankline Mauzas (area = 16,661 ha)

Reach	1981 Population per km²	1993 Population per km²	Percent Change
Upper	-	-	-
Middle	174	212	+21
Lower	197	54	-73
Mean	172	150	-13
Total	28,719	24,955	-3,764

Source: BBS 1981 Census; inventory data; FAP 19 satellite image analysis

1993, much higher than overall population growth in the Ganges charlands. Figure 3.5 showed relatively high population growth in accreting within-bank chars in this area, and the RRA found organized in-migration into these chars. This may be associated with shifts in the population, as there has been a decline on the mainland near the international border. In the lower reach, the inventory suggests a major decline in within-bank population (Table 4.7); these mauzas in 1993 had only 54 people per km^2. This may in part be a consequence of people shifting to more stable land as "mainland" accreted and the within-bank area declined, and therefore, the area occupied by river channels between the banklines increased. Now much of the lower reach within-bank area comprises sand and water in the dry season, and is presumably almost all flowing water in the monsoon.

The within-bank chars do not appear to have absorbed people displaced by bank erosion. Even in the middle reach, where the area of vegetated chars increased during 1984-93, population growth in within-bank mauzas was slightly less than the Bangladesh average. At best, a limited number of erosion victims may have moved into these chars, while in the lower reach people are likely to have moved from the narrowing channel into adjacent land that is now outside the banklines.

The equivalent figures for mainland mauzas unaffected by erosion show a one percent decline in population. Since mainland mauzas generally experienced slow population growth (Section 3.2), most of that growth occurred in mauzas overlapping the banklines. Table 4.8, however, reveals wide variations in the population trend according to reach and bank. In the upper reach, where few people live in the small south bank area within Bangladesh, overall population in unaffected mainland mauzas only grew by 4 percent.

There was a large population decline in the middle reach mainland mauzas (accounting for the overall decline). The decline here clearly affected mauzas that did not experience bank erosion, and more people were involved than could have moved to the within-bank chars. These changes, then, were due to factors other than changing river morphology. The reasons for this reported decline in mainland population deserve further investigation.

Population in the unaffected mainland of the lower reach grew by 24 percent. Although this is the most densely populated part of the study area, its

Table 4.8 Population Growth in Unaffected Mainland Mauzas (area = 46,716 ha)

Reach	Percent Growth/Decline 1981-93	
	West	East
Upper	63	3
Middle	-66	-38
Lower	32	14
Average	-15	5
Total Population 1981	80,640	202,259
Total Population 1993	68,303	212,133
People per km² 1981	522	647
People per km² 1993	443	678

Source: BBS Census 1981; inventory 1993

population grew by the Bangladesh average rate. With low erosion and high accretion, the mainland here was presumably stable.

The results confirm that the population dynamics of the three Ganges reaches are very different. While the within-bank population of the lower reach has fallen, it has grown in mainland areas. There has been net accretion, with an apparent shift of population from eroded to accreted land. The only areas with population growth in the middle reach were within-bank mauzas. Char accretion may have attracted some people into these areas, but there were even greater declines in population in mainland unaffected by erosion, and a further displacement due to bank erosion. In the upper reach, there are no completely within-bank mauzas to compare with changes in the mainland, but there was minimal population growth in mainland mauzas. This implies that the many people estimated to have been displaced by erosion moved away from the charlands.

4.4.3 Estimated Population Impacts of Erosion

Out of the total 1981 study area population of about 653,000 people, 72 percent are estimated to have lived on mainland that has not eroded. Population growth at the national average rate would have resulted in about 616,000 people in 1993. The inventory estimate in 1993 was 548,414 people. Likewise, if the population living between the banklines in 1984 continued to grow at the national average rate, the population in 1993 would have been 168,500, 25,500 more than the 1993 inventory figure. Therefore, population growth has been much lower than the national average, even in areas not affected by bank erosion. Since the reasons for this difference from the national trend are not known, predicting the impacts of erosion is difficult, particularly since there may have been movements across the border.

It appears that in the upper reach all the estimated 19,000 people displaced by bank erosion since 1984 moved out of the study area. In the middle reach, more people left the unaffected mainland between 1984 and 1993 than were living on land that eroded in that period. There appears to have been general depopulation from mainland in this area, and only a moderate increase in the population on within-bank chars. It is possible, therefore, that people would have left even without bank erosion. Accretion of new land in the lower reach more or less compensated for the loss of land due to bank erosion, since it supports somewhat higher population densities than the eroded land. Consequently, between 19,000 and 44,000 people, or 3 to 6 percent of the 1981 population, may have been forced to leave the charlands because of erosion.

4.5 Implications of Analysis

Compared with the other main rivers, bank erosion has not been a major problem in the Ganges charlands. Nevertheless, in limited areas people have lost their land and homes. Using the inventory together with satellite image analysis for two years makes aggregate estimates of erosion impacts possible for the first time.

About 8 percent of the 1981 population of the Ganges charlands are estimated to have been displaced by bank erosion between 1984 and 1993, and between 3 and 6 percent of the 1981 population are thought to have left the charlands by 1993. In the Jamuna River, char-building processes between 1980 and 1992 created land that could accommodate some of the erosion victims, but this has only been the case to a limited extent in the middle and lower Ganges. New chars have emerged, particularly in the middle reach, and the RRA found some in-migration into these areas, but the local power structure and dominance of large landlords affects the pattern of re-population. In the lower reach, chars have consolidated and the within-bank area reduced, resulting in new land outside the banklines to compensate for that lost to erosion. Whether erosion victims have access to this land can only be determined by detailed local investigation, but the evidence from the middle-lower reach RRA suggests that they may not have ready access to accreted land.

The Ganges upstream of the Jamuna confluence has followed approximately the same course for more than 200 years. It also shows less braiding and tends to be a single channel for much of the area studied. Consequently, bank erosion has been relatively low compared with the other rivers, so the number of people affected is less than along the other rivers, but is still locally important.

Further study is needed to understand the reasons for low population density, and an apparent tendency for depopulation unrelated to erosion. This might also be helped by comparative analysis of 1971 and 1991 population census data and bankline changes from the 1973 and 1980 Landsat images, as well as 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 Ganges and are likely to continue. The island chars formed within the migrating and widening channel are unable to take up the displaced population, and may appear on the wrong side of the border from the erosion victims. Flood proofing may offer a partial solution 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.

Since much of the Ganges is bordered by embankments that do not appear to be threatened by severe bank erosion, the future may lie in facilitating flood proof villages on the embankments. These would help residents commute from a secure base to low-lying chars for dry season cultivation and grazing. Localized stabilization of island chars in the middle reach 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 somewhat more closely associated with age of land category than with char land type, but many other factors must be involved in determining population density.

2. The inventory was not expected to obtain accurate estimates of areas eroded, but to act as a cross-check with the image analysis, and as a starting point for assessment of homesteads lost to erosion.

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

One issue raised by the inventory mapping, which is more important in the Ganges charlands than for the other main rivers, is the lack of accurate, up-to-date maps delineating mauza boundaries. Moreover, areas of *khas* land have emerged in recent years and are being occupied, but their status is uncertain. Surveys to revise the cadastral mapping of these charlands are needed. This would ensure that the spatial content of census and inventory data is correct, and that officials and elected representatives have accurate information about their service areas and constituents.

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 Ganges charlands differences between reaches (Table 5.3) are as important for aspects such as flood hazard, as differences between char land types (Tables 5.1 and 5.2). While in part this reflects differences between reaches in the composition of land types (for example, there is a concentration of island char

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

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

Source: FAP 16 Charland Inventory

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

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

Source: FAP 16/19 inventory and satellite image analysis

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

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

Table 5.3 **Summary of Mauza Inventory Data by Reach - Ganges**

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

Source: FAP 16/19 inventory and satellite image analysis
*BBS (1993), except flood data, which is from Rogers, *et al.* (1989). Population figures are for 1991. Comparisons are for rural Bangladesh.
†Facilities below the union health center level, such as private doctors, may have been included in the inventory.

land in the middle reach), the three reaches have clearly distinct environments and economic circumstances:

- the upper reach has a large area of unprotected mainland between the Ganges and Mahananda and a very narrow band of charland downstream of Godagari Thana, and the entire south side of the reach is bounded by the international border;
- the middle reach comprises a large dynamic island char complex and broad area of charland upstream of Hardinge Bridge, and part of the area is bounded by the international border; and
- the lower reach is relatively narrow and is bounded on both sides by embankments (except at the Gorai off-take).

This report presents only very aggregated maps, more detailed maps, covering smaller reaches of the Ganges, can be produced from the GIS database for specialized uses.

Analysis of Landsat images from 1984 and 1993 revealed bank erosion in the upper and middle reaches, where the Ganges meanders are more pronounced, and net accretion along the banklines in the lower reach (Chapter 2). The Ganges has followed the same course for many years, and the active river corridor is relatively well defined and bounded by embankments along much of its length in Bangladesh. Comparison of the images and historical maps reveals that the lower reach is much less meandering now than in the 1770s, and that the actively braided band has narrowed in the past decade. Erosion on meander bends, however, has consumed substantial areas within the active corridor in the past decade.

Chapters 3 and 4 reveal that factors other than morphological changes are likely to have been behind many of the population trends in the study area. People in the upper reach mainland were displaced by bank erosion, and are presumed to have moved out of the study area. In the middle reach, many mainland people appear to have left their mauzas (only some of which were affected by erosion); some have moved into newly accreted chars, but many must have left the area. The population growth rate in the lower reach, while comparable to the national average, has increased most in charland that consolidated into mainland since 1984 (when this land was within the monsoon season banklines), as the channel narrowed.

An estimated 19,000 to 44,000 people (3 to 6 percent of the population) were displaced by bank erosion between 1984 and 1993. If the meanders in the upper and middle reach continue to erode unprotected mainland, this trend may persist, but the reasons for population changes in these border areas may be complex. Morphological changes affect the charlands on both sides of the international border, and more detailed study of local changes would be needed to understand the patterns.

5.3 Future Uses of Ganges 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 Ganges within Bangladesh, but similar analysis would be possible for smaller planning areas within this study area. 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 Ganges charlands falls between the boundaries of two FAP regional studies. No detailed feasibility studies have so far been proposed for the nearby mainland, but embankments already exist for much of the study area boundary. The continued management of these flood control projects would benefit from the morphological analysis and erosion trends revealed by the satellite images, which show areas where structures may be threatened by erosion. The needs of people living on the river side of these embankments (the charlands) should also be considered, as these people are most affected by floods. Linkages between existing projects and possible 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 south (right) bank of the Ganges study area. There already are embankments along much of this bank of the Ganges within Bangladesh, excepting the Gorai off-take and part of the middle reach near the Indian border. FAP 4 (1993) concluded that Ganges embankments had not adversely affected the river's morphology, but embankments closer to the river have been proposed at some locations.

Measures to keep the Gorai open and increase its dry season flow have been suggested. The decline in Ganges flow in the dry season between 1984 and 1993 may explain the increased char area estimated from satellite images, and in the lower reach it may have created more usable land in the dry season. Such areas are unlikely to be habitable in the monsoon. Potential implications of any measures that would alter dry season flows for Ganges charlands downstream of the off-take of the Gorai distributary need to be assessed. The impacts might not be large, but there are some 260,000 people living in the adjacent lower reach charlands.

5.3.3 Northwest Regional Study (FAP 2)

A continual Bangladesh Water Development Board (BWDB) embankment already exists along the north (left) bank of the Ganges from the outfall of the Mahananda to the Jamuna confluence. FAP 2 used it as the boundary of its study area, but did not undertake any study of the Ganges charlands. Any impact from these embankments has already occurred, but erosion trends need to be monitored in case they threaten the embankments.

The extent to which these embankments act as a shelter for char people in severe floods should be investigated. Most houses in the Ganges charlands were flooded in 1988, and there may be ways that the BWDB embankments can benefit char people by serving as temporary shelters. If dry-season charland continues to emerge, they could even act as permanent village sites, enabling people to cultivate the new chars from the safety of homesteads that would not be flood-prone.

5.3.4 Flood Modelling

FAP 25 (1993) has modelled the potential impacts of embankments along the main rivers of Bangladesh. For the Ganges, scenarios 4, 5, and 6 in FAP 25 (1993) assumed the right bank embankment would be improved and moved closer to the river in a few places. Table 3.28 reports the predicted increases in flood level, and indicates that confinement of the Ganges would have a minimal effect on normal and peak flood levels.

The one exception is at Mahendrapur, close to the Jamuna confluence, where embankment changes and proposed interventions along the Jamuna could result in a backwater effect that would raise all peak water levels by about 18 cm. This is about 70 percent of the increase in peak water level in the lower reach between the 1987 and 1988 flood peaks (which resulted in 27 percent of houses in the lower reach being destroyed compared with 8 percent in the previous year). Flood proofing and charland development programs in the Ganges charlands 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 in the lower reach such measures may be needed if interventions in the Jamuna go ahead.

Although Chapter 2 showed that the Ganges course changes, it is less dynamic than the other main rivers and may be in a state of dynamic equilibrium. The limitations of the flood modelling, therefore, should result in less uncertainty about potential changes than in the other main rivers. The greatest uncertainty concerns upstream changes in the catchment, which lies outside Bangladesh.

5.3.5 Morphology Studies

The analysis of Chapter 2 has already shown that the Ganges charlands have changed considerably in the recent past (1984-1993), and indicated greater 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.

There already are major investments in embankments along the Ganges, and the movements of the Ganges meanders should be more predictable than the movements of more braided rivers. Monitoring of erosion trends and predictions of future erosion would help to determine any need for protection works along the Ganges well in advance of the embankment being threatened. This would help in programming maintenance of these works. Monitoring of changes in response to changed low flow regimes is also needed. This study has demonstrated how this could be achieved through integration of the satellite image and inventory analysis with modelling of morphological changes.

Trends in the morphology of the Ganges in Bangladesh cannot be seen in isolation, much of the study area is bounded by India. On the south (right) bank of the upper reach, and upstream, substantial erosion is reported, threatening infrastructure and taking some 30,000 ha of land between 1931 and 1987 (Verghese, 1990). It is reported that India proposed a Rs 1,980 million anti-erosion project for the Ganges in 1980. Any measures to train the Ganges should take account of the whole river and of impacts on char people on both sides of the border.

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 Ganges charlands, particularly in the middle reach, and they are not expected to decrease. Although erosion risk is quite high in the dynamic island chars, islands may persist for longer than in the other rivers. This should be confirmed by analyzing a series of satellite images and, if found to be correct, small-scale flood proofing works should be considered as a means of counteracting changes in flood risk, and of improving the lives of char people 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 Ganges, 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 many NGOs active in the Ganges charlands, but they concentrate their efforts on the unprotected mainland. The inventory indicates that there are still many ways in which these NGOs could help char people improve their livelihoods and lower their vulnerability to flood and erosion impacts. NGOs active in the area could use the inventory data to identify priority issues and their locations and extent for planning their programs. If NGOs are to extend their activities in this way they will need information on hazard risks to avoid loss of expensive infrastructure.

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, and a national database on these diverse and complex areas has been compiled. This information needs to be properly used and taken into account by the full range of ministries and departments that could and should be actively involved in improving the livelihoods of char people.

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

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

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APPENDIX A

QUESTIONNAIRE FOR THE MEGHNA, PADMA, AND GANGES CHARLAND INVENTORIES

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?......% |_|_|_|

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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)..........]

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 ____________________________________

____

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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 <u>Socio-Economic and Agricultural Conditions</u>

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	

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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)		

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:..................

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 **Hazard Occurrence and Losses**

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			

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 ব্যক্তি; ৮. স্থানীয় ক্লাব/সংস্থার কর্মকর্তা/প্রতিনিধি; ৯. অন্যান্য (উল্লেখ করুন)।

নোট : যেসব ক্ষেত্রে তথ্য "পাওয়া যাবে না" সেসব ক্ষেত্রে কোড নং '-৯' 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, ছ২, ছ৩, ছ৪, ছ৫ 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)

১৫৫

চর ভূমির গঠন ও প্রকৃতিগত প্রেক্ষাপট

কোড

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 অংশে কোন ধরনের চরের অন্তর্ভূক্ত 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 ভূমির 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

(ছোট জায়গার বেলায় একরে পরিমাণ নির্ণয় সহজ হইবে, যদি তাই করা হয় তবে তা পরিষ্কারভাবে লিখতে হবে)। প্রথম কলামের যোগ ১০০% হবে। এখানে বালুময়, বাসাবাড়িত, চাষকৃত ভূমি অন্তর্ভূক্ত 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 অংশে 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 অংশে (জনগণের সাধারণ ব্যবহার্য) ব্যক্তিমালিকানাধীন নয় ? %

এ- খ.১০ এর শতকরা কত অংশে 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 কোড় ০ 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 দ্বীপচর, 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 আর 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 ধরণ 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।

কোড

গ.৪ বসতি স্থাপনের কাল ঃ

১. সাময়িক	২. অস্থায়ী	৩. স্থায়ী

সংগা ঃ সাময়িক– প্রতি বৎসরের কিছু সময়কাল/নির্দিষ্ট সময়কাল অবস্থান করেন (শুষ্ক 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 জেনে 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 (যেমনঃ 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

হালট/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 স্থলপথ, ২. সারা বৎসর নৌকায়, ৩. শুধুমাত্র বর্ষাকালে নৌকায়

কোড

৬ 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 (যেমনঃ 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

ঙ. আর্থ–সামাজিক এবং কৃষি বিষয়ক অবস্থা

ঙ.১ মৌজা/গ্রামের খানাসমূহের জীবনধারনের প্রধান অবলম্বন/উপায়সমূহ কি?

মূল 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)

ঙ.২ ফসলের নিবিড়তা : মৌজা/গ্রামে গত বৎসরের চাষকৃত জমির শতকরা কত অংশ নিম্নোল্লেখিত ধরনের অন্তর্ভুক্ত ছিল।

নির্দেশিকা– *(জমির পরিমাণ কম হলে যথার্থ সংখ্যা একরে নোট করে তারপর শতকরা হারে হিসাব করে লিখুন)*

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

ঙ.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 অল্প জমিতে চাষ করা হয় সেসব ক্ষেত্রে জমির পরিমাণ একরে নোট করে তা ঙ.১০ 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 (শুষ্ক বা বর্ষায়) শতকরা যে পরিমাণ আবাদযোগ্য জমি চাষ করা যেতো, কিন্তু সর্বোচ্চ বন্যায় ডুবিয়ে ছিলো। কতদিন ডুবিয়ে ছিলো তা সর্বোচ্চ বন্যার সময় থেকে বিবেচনা করবেন।]

চ.২ গত ছয় বৎসরে ভাঙ্গনের 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, যেমনঃ 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/এরও 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? হ্যাঁ / না

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

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

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

২৮

তত্ত্বাবধায়কের স্বাক্ষর ও তারিখ

তথ্যসংগ্রহকারীর পূর্ণনাম স্বাক্ষর ও তারিখ

১৬২

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।

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 South	Attached South	Island Char	Submerged	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	-	9489	11124	571	10034	29709	19523	29709	60926
Middle	11031	1715	24755	55	1704	1982	3419	13013	41242
Lower	14902	3812	10959	159	18823	5976	22636	20878	54632
Total	25933	15016	46837	785	30561	37667	45578	63600	156800

Source: FAP 19 Satellite Images 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 South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	1724	2620	1111	2244	2834	2244	7698
Middle	864	266	4899	227	413	493	1277	6669
Lower	1937	939	2988	2580	306	3519	2243	8750
Total	2800	2929	10507	3918	2963	6847	5763	23117

Source: FAP 19 Satellite Images 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 South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	2319	4735	1149	1326	3468	1326	9530
Middle	939	410	9230	313	326	723	1265	11218
Lower	1690	1158	3880	3452	85	4610	1775	10265
Total	2629	3888	17845	4914	1737	8802	4366	31013

Source: FAP 19 Satellite Images 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 South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	5446	4339	7773	26139	13220	26139	43698
Middle	9228	1038	10681	1164	1243	2203	10471	23354
Lower	11276	1715	4250	12791	5585	14506	16861	35617
Total	20504	8200	19270	21729	32967	29929	53471	102670

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

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

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	4890	5033	7605	21420	12495	21420	38947
Middle	8496	1261	13261	1186	1688	2447	10183	25891
Lower	10884	2238	4853	12859	4600	15097	15485	35435
Total	19380	8389	23147	21649	27708	30038	47088	100273

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

Table B.6 Population Numbers 1981

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	13800	13616	38151	211726	51951	211726	277293
Middle	88044	4885	38256	3003	22979	7888	111023	157167
Lower	93321	11275	16680	48869	49046	60144	142367	219191
Total	181365	29960	68552	90023	283751	119983	465116	653651

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

Table B.7 Population Numbers 1993

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	24021	13180	40278	240597	64299	240597	318076
Middle	71132	3260	33314	4985	16560	8245	77692	119251
Lower	113726	12659	7901	56042	68965	68701	182691	259293
Total	184858	39940	54395	101305	316122	141245	500980	696620

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 South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper		253	118	401	809	329	809	526
Middle	644	190	134	292	835	241	596	289
Lower	763	331	72	298	1153	303	875	476
Total	712	266	116	331	839	310	787	446

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

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

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached Mainland	Sub Total Unprotd	Total
Upper	0	108	-18	21	77	63	77	55
Middle	-153	-95	-20	116	-828	10	-256	-92
Lower	137	-83	-80	38	333	18	193	65
Total	13	36	-34	37	70	37	47	20

Source: FAP 16 Field Survey and BSS Small Area Atlases Apportioned by Predominant Charland Type

Table B.10 Population Densities in 1993 per Km Square of Cultivated/Vegetated Land Area .

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	441	304	518	901	486	901	716
Middle	771	314	312	428	528	374	742	511
Lower	1009	738	186	438	1235	474	1084	728
Total	902	487	282	466	943	472	927	673

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

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

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	309	145	451	857	385	857	588
Middle	700	225	167	338	418	282	662	345
Lower	877	441	97	345	1216	359	980	565
Total	799	330	147	380	896	365	857	517

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

Table B.12 Household Numbers 1993

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	4324	2440	7473	42736	11797	42736	56973
Middle	13134	550	6103	982	1290	1532	14424	22059
Lower	19489	2408	123	9411	11834	11819	31323	44415
Total	32623	7282	9816	17866	55860	25148	88483	123447

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

Table B.13 Mean Household Size

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	-	5.6	5.4	5.4	5.6	5.5	5.6	5.6
Middle	5.4	5.9	5.5	5.1	12.8	5.4	5.4	5.4
Lower	5.8	5.3	6.2	6.0	5.8	5.8	5.8	5.8
Total	5.7	5.5	5.5	5.7	5.7	5.6	5.7	5.6

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

Table B.14 Number of Permanent Out-Migrant Households in 1993

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	56	0	0	102	56	102	158
Middle	0	0	0	0	0	0	0	0
Lower	373	0	5	0	30	0	403	408
Total	373	56	5	0	132	56	505	566

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

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

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	-	1.30	0.00	0.00	0.24	0.47	0.24	0.28
Middle	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lower	1.91	0.00	0.39	0.00	0.25	0.00	1.29	0.92
Total	1.14	0.77	0.05	0.00	0.24	0.22	0.57	0.46

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

Table B.16 Number of Permanent In-Migrant Households 1993

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	50	50	30	708	80	708	838
Middle	229	0	208	75	58	75	287	570
Lower	112	99	15	251	105	350	217	582
Total	341	149	273	356	871	505	1212	1990

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

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

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	-	1.16	2.05	0.40	1.66	0.68	1.66	1.47
Middle	1.74	0.00	3.41	7.64	4.50	4.90	1.99	2.58
Lower	0.57	4.11	1.18	2.67	0.89	2.96	0.69	1.31
Total	1.05	2.05	2.78	1.99	1.56	2.01	1.37	1.61

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

Table B.18 Number of Seasonal Out-Migrants 1993

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	15	198	0	1160	15	1160	1373
Middle	127	0	92	0	34	0	161	253
Lower	24	7	2	40	182	47	206	255
Total	151	22	292	40	1376	62	1527	1881

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 South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper		0.06	1.50	0.00	0.48	0.02	0.48	0.43
Middle	0.18	0.00	0.28	0.00	0.21	0.00	0.21	0.21
Lower	0.02	0.06	0.03	0.07	0.26	0.07	0.11	0.10
Total	0.08	0.06	0.54	0.04	0.44	0.04	0.30	0.27

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

Table B.20 Number of Seasonal In-Migrants 1993

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	10	25	0	566	10	566	601
Middle	24	0	38	5	4	5	28	71
Lower	0	0	0	83	15	83	15	98
Total	24	10	63	88	585	98	609	770

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

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

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	-	0.04	0.19	0.00	0.24	0.02	0.24	0.19
Middle	0.03	0.00	0.11	0.10	0.02	0.06	0.04	0.06
Lower	0.00	0.00	0.00	0.15	0.02	0.12	0.01	0.04
Total	0.01	0.03	0.12	0.09	0.19	0.07	0.12	0.11

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 South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	8	8	7	69	15	69	92
Middle	12	2	11	2	4	4	16	31
Lower	49	4	2	13	33	17	82	101
Total	61	14	21	22	106	36	167	224

Source: FAP 16 Field Survey

Table B.23 Number of Mauzas with High School

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	2	2	3	25	5	25	32
Middle	8	0	2	0	4	0	12	14
Lower	15	0	0	3	9	3	24	27
Total	23	2	4	6	38	8	61	73

Source: FAP 16 Field Survey

Table B.24 Number of Mauzas with Health Care Facilities

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	2	0	2	18	4	18	22
Middle	3	0	2	0	1	0	4	6
Lower	9	1	1	4	16	5	25	31
Total	12	3	3	6	35	9	47	59

Source: FAP 16 Field Survey

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

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	2499	1138	2744	19050	5243	19050	25431
Middle	5462	245	1967	510	394	755	5857	8579
Lower	6787	968	447	4531	5960	5499	12747	18693
Total	12249	3712	3552	7785	25404	11497	37653	52702

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 South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	-	57.8	46.6	36.7	44.6	44.4	44.6	44.6
Middle	41.6	44.5	32.2	51.9	30.5	49.3	40.6	38.9
Lower	34.8	40.2	35.1	48.1	50.4	46.5	40.7	42.1
Total	37.5	51.0	36.2	43.6	45.5	45.7	42.6	42.7

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

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

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	377	138	63	483	440	483	1062
Middle	65	0	414	31	148	31	212	657
Lower	990	218	127	310	230	528	1220	1875
Total	1054	596	679	403	861	999	1916	3594

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

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

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	-	8.7	5.7	0.8	1.1	3.7	1.1	1.9
Middle	0.5	0.0	6.8	3.2	11.5	2.0	1.5	3.0
Lower	5.1	9.1	10.0	3.3	1.9	4.5	3.9	4.2
Total	3.2	8.2	6.9	2.3	1.5	4.0	2.2	2.9

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

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

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0.0	7.7	7.0	0.1	3.8	2.9	3.8	3.8
Middle	1.6	0.0	10.5	9.0	15.3	5.7	2.8	5.1
Lower	7.6	10.9	11.5	7.4	7.4	8.1	7.6	7.8
Total	5.2	8.2	9.8	4.4	4.8	5.5	5.0	5.5

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	36.2	45.7	42.6	42.7
Fishing	6.9	4.0	2.2	2.9
Agric.Labor	35.9	26.9	32.0	31.3
Non Agric. Labor	6.3	5.9	7.5	7.1
Transport	2.2	2.3	1.7	1.9
Petty Business	6.4	10.7	8.4	8.7
Large Business	.0	1.1	.5	.6
Service	.5	1.0	2.9	2.3
Paid HH Work	.9	2.0	1.4	1.4
Remit.From Abroad	.1	.0	.2	.2
Others	4.4	.4	.5	.8
No Livelihood	.1	.0	.2	.2
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 South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	-	196	191	201	188	199	188	191
Middle	181	162	168	162	171	162	180	173
Lower	188	201	172	182	190	184	188	185
Total	185	192	174	188	187	189	186	185

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

Table B.32 Average Percentage of Sandy Land Reported

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	-	42	65	32	21	38	21	29
Middle	29	13	60	40	28	34	28	42
Lower	16	42	58	48	15	46	15	33
Total	19	41	60	45	20	44	20	34

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland 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	4.8	1.2	0.8	1.2	0.6	0.8	0.9
Groundnut	13.7	5.5	2.5	0.2	11.3	8.2	5.5
Dhal	24.9	37.6	32.0	48.6	7.8	28.4	32.3
Onion	8.2	5.8	6.4	4.3	11.4	6.1	6.6
Til	1.4	2.2	1.0	1.4	1.4	1.5	1.4
Chilli	1.5	4.1	2.8	1.8	4.2	3.4	2.9
Wheat	14.2	17.2	17.3	14.5	18.0	18.5	16.7
Potato	1.7	2.0	1.3	1.3	2.8	1.1	1.6
Sweet Potato	4.9	1.0	0.9	0.2	4.3	1.8	1.7
Mustard	1.5	3.0	4.4	3.9	3.9	2.6	3.5
L Boro	12.8	4.3	3.7	2.1	12.8	5.0	5.6
HYV Boro	2.6	9.0	11.5	11.5	6.2	8.1	9.1
Aus	52.8	64.2	61.1	77.6	40.1	52.8	60.4
Jute	10.5	6.8	10.0	6.0	14.3	9.6	9.1
B Aman	5.5	5.2	9.8	0.3	11.0	14.5	7.6
TL Aman	1.4	3.3	2.9	1.0	2.2	5.3	2.7
HYV Aman	1.2	1.8	1.5	0.4	1.6	2.8	1.5
Sugarcane	5.6	4.6	12.1	5.2	13.2	9.9	8.7
Dhaincha	1.0	0.8	0.8	0.2	2.8	0.3	0.8
Others	0.8	5.0	1.3	3.8	0.5	1.6	2.3
Total	171.0	184.6	184.1	185.5	170.4	182.3	180.9

Source: FAP 16 Inventory Survey

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

Crop	Island Char	Attached Char	Unprotected mainland	Total
Kaon	1.15	1.00	1.09	1.08
Groundnut	1.50	1.52	1.56	1.53
Dhal	1.14	1.26	1.31	1.28
Onion	7.13	8.25	9.29	8.76
Til	1.00	1.04	0.89	0.96
Chilli	1.78	2.28	1.95	2.01
Wheat	1.98	2.11	2.15	2.12
Potato	17.60	18.12	16.43	16.92
Sweet Potato	18.23	17.90	19.00	18.55
Mustard	0.96	1.07	1.10	1.09
L Boro	2.04	2.07	1.98	2.02
HYV Boro	5.22	4.42	4.34	4.38
Aus	1.85	1.77	1.79	1.79
Jute	1.78	1.66	1.68	1.69
B Aman	1.65	1.93	1.97	1.93
TL Aman	2.77	2.48	3.24	3.08
HYV Aman	4.15	3.50	4.37	4.22
Sugarcane	57.25	55.69	45.00	47.22

Source: FAP 16 Inventory Survey

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

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	12	11	4	19	16	19	46
Middle	11	0	26	0	11	0	22	48
Lower	33	14	26	23	18	37	51	114
Total	44	26	63	27	48	53	92	208

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

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

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	8182	5835	20700	56315	28882	56315	91032
Middle	3028	79	5938	339	1505	418	4533	10889
Lower	27994	4805	373	4555	6940	9360	34934	44667
Total	31022	13066	12146	25594	64760	38660	95782	146588

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 South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	5361	4677	17286	50166	22647	50166	77490
Middle	2667	79	5277	339	1311	418	3978	9673
Lower	24148	4065	336	3891	5297	7956	29445	37737
Total	126815	9505	10290	21516	56774	31021	83589	124900

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 South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	150	134	266	215	218	215	208
Middle	33	8	56	29	121	19	43	47
Lower	248	280	9	36	124	65	207	125
Total	151	159	63	118	196	129	179	143

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 South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	105	64	232	205	173	205	171
Middle	30	5	30	23	96	14	39	31
Lower	216	167	5	28	122	49	187	97
Total	134	108	33	96	187	100	166	110

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 South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	189	239	277	132	245	132	160
Middle	23	14	97	35	117	27	31	49
Lower	144	200	29	48	59	79	112	101
Total	95	179	124	143	116	154	108	119

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 South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	7600	6504	16340	52764	23940	52764	83208
Middle	3535	100	4941	130	810	230	4345	9516
Lower	27922	5080	495	5390	6008	10470	33930	44895
Total	31457	12780	11940	21860	59582	34640	91039	137619

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 South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	98	72	183	192	143	192	156
Middle	35	7	25	9	52	8	37	28
Lower	215	177	6	33	106	55	182	98
Total	136	106	32	82	172	89	157	103

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 South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	176	267	219	123	203	123	146
Middle	27	18	81	13	63	15	30	43
Lower	143	211	39	57	51	89	108	101
Total	96	176	122	122	107	138	103	111

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

Table B.44 Total Number of Poultry in 1993

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	25100	15850	31270	165466	56370	165466	237686
Middle	31298	1250	18036	1950	4645	3200	35943	57179
Lower	67446	15170	4303	35455	41950	50625	109396	164324
Total	98744	41520	38189	68675	212061	110195	310805	459189

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

Table B.45 Ratio of Poultry Per 100 Human Households in 1993

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	580	650	418	387	478	387	417
Middle	238	227	296	199	360	209	249	259
Lower	346	630	338	377	354	428	349	370
Total	303	570	389	384	380	438	351	3721

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 South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	333	506	467	1530	800	1530	2836
Middle	77	0	445	82	163	82	240	767
Lower	1236	347	171	672	399	1019	1635	2825
Total	1313	680	1122	1221	2092	1901	3405	6428

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 South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	13	5	16	28	15	28	20
Middle	171	0	14	12	8	19	60	29
Lower	16	7	7	14	30	12	19	16
Total	25	11	9	15	27	13	26	19

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

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Table B.48 Number of Mechanized Boats in 1993

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	38	70	121	228	159	228	457
Middle	4	0	82	33	31	33	35	150
Lower	139	15	25	73	38	88	177	290
Total	143	53	177	227	297	280	440	897

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

Table B.49 Households Per Mechanized Boats in 1993

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	114	35	62	187	74	187	125
Middle	3284	0	74	30	42	46	412	147
Lower	140	161	51	129	311	134	177	153
Total	1228	137	55	79	188	90	201	138

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 South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	0	0	0	36	0	36	36
Middle	12	0	88	0	19	0	31	119
Lower	40	18	0	16	2	34	42	76
Total	52	18	88	16	57	34	109	231

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

Table B.51 1988 Floods Deaths per 100,000 People (1993 Population)

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	0	0	0	15	0	15	11
Middle	17	0	264	0	290	0	40	100
Lower	35	142	0	29	3	49	23	29
Total	28	45	162	16	18	24	22	33

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

Table B.52 Number of Human Deaths from Epidemic Disease 1988-92

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	70	10	9	158	79	158	247
Middle	32	0	143	0	86	0	118	261
Lower	121	31	4	57	30	88	151	243
Total	153	101	157	66	274	167	427	751

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 South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	291	76	22	67	123	67	79
Middle	45	0	429	0	519	0	152	219
Lower	106	245	51	102	44	128	83	94
Total	83	253	289	65	88	118	86	108

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 South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	66	72	63	37	64	37	48
Middle	100	100	95	100	99	100	100	98
Lower	89	87	97	96	77	95	85	90
Total	94	75	90	84	46	81	64	74

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type
Note: 26 Mouzas with Missing Data.

Table B.55 Mean Days Duration of Flooding 1987

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	21	23	14	11	18	11	13
Middle	47	45	41	46	37	46	42	42
Lower	32	26	31	30	.21	29	28	28
Total	35	25	35	29	18	27	24	27

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type
Note: 27 Mouzas with Missing Data

Table B.56 Percentage of Area Flooded at Peak Flood Time 1988

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	100	98	91	97	95	97	97
Middle	100	100	100	100	100	100	100	100
Lower	100	100	100	100	100	100	100	100
Total	100	100	100	97	98	98	99	99

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type
Note: 26 Mauzas with Missing Data.

Table B.57 Mean Days Duration of Flooding 1988

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	31	33	27	30	29	30	30
Middle	53	46	50	49	42	48	48	49
Lower	45	41	41	39	30	40	39	39
Total	46	37	44	38	32	38	37	39

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type
Note: 28 Mauzas with Missing Data.

Table B.58 Percentage of Area Flooded at Peak Flood Time 1991

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	28	90	56	81	44	81	71
Middle	86	74	90	93	88	84	86	87
Lower	73	62	82	86	59	83	68	76
Total	78	41	88	75	78	66	78	76

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type
Note: 26 Mauzas with Missing Data.

Table B.59 Mean Days Duration of Flooding 1991

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	16	29	14	16	15	16	17
Middle	30	26	30	38	27	36	28	29
Lower	21	22	24	22	18	22	20	21
Total	23	20	27	22	18	22	20	22

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type
Note: 41 Mauzas with Missing Data.

Table B.60 Percentage of Area Flooded During 1989-92

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	37	80	56	66	48	66	62
Middle	83	74	86	95	84	85	83	85
Lower	72	62	79	80	53	78	65	72
Total	77	47	83	72	64	65	69	70

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type
Note: 26 Mauzas with Missing Data.

Table B.61 Mean Days Duration of Flooding 1989-92

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	17	30	13	14	16	14	16
Middle	31	28	28	39	26	36	28	29
Lower	21	21	22	22	17	21	20	20
Total	24	20	26	22	17	21	19	21

Source: FAP 16 Field Survey Estimates Apportioned by Predominant Charland Type
Note: 42 Mouzas with Missing Data.

Table B.62 Percentage of Households which are all Kutcha

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0.0	19.8	54.1	9.9	26.9	13.5	26.9	25.3
Middle	53.9	65.1	64.5	18.7	42.2	35.3	52.9	54.9
Lower	57.9	36.2	59.5	54.3	28.2	50.6	46.7	48.1
Total	56.3	28.6	61.3	33.7	27.5	32.3	38.1	38.8

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

Table B.63 Number of Households per Radios by Reach and Char Type

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0.0	7.4	3.0	6.5	5.3	6.8	5.3	5.3
Middle	38.7	50.0	13.2	57.8	6.6	54.7	27.0	21.5
Lower	7.1	6.1	7.0	9.3	6.1	8.4	6.7	7.1
Total	10.6	7.3	6.7	8.2	5.4	7.9	6.6	6.9

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 South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	13	18	31	13	21	13	15
Middle	55	63	70	28	66	45	61	63
Lower	54	48	32	38	13	41	38	39
Total	54	34	51	37	19	36	32	34

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

Table B.65 Percentage of Houses Destroyed by Flood 1987

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	2	12	1	4	1	4	4
Middle	0	0	9	8	8	4	4	6
Lower	14	12	0	3	1	5	9	8
Total	11	7	8	3	3	4	6	6

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

Table B.66 Percentage of Houses Flooded in 1988

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	58	60	37	76	49	76	71
Middle	80	80	97	54	83	67	81	86
Lower	99	99	96	98	90	98	96	96
Total	95	80	88	86	81	84	86	86

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

Table B.67 Percentage of Houses Destroyed by Flood 1988

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	35	20	4	28	21	28	27
Middle	12	0	45	18	21	9	17	25
Lower	37	32	12	22	17	24	29	27
Total	32	31	33	19	24	23	27	27

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

Table B.68 Mean Percentage of Houses Flooded 1989-92

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	3	10	3	4	3	4	4
Middle	0	0	2	0	0	0	0	1
Lower	1	0	6	5	2	4	1	2
Total	1	1	4	4	3	3	2	3

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

Table B.69 Mean Percentage of Houses Destroyed by Flood 1989-92

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0.0	0.0	1.8	0.0	0.7	0.0	0.7	0.7
Middle	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lower	0.0	0.0	1.1	0.6	0.2	0.5	0.1	0.2
Total	0.0	0.0	0.7	0.5	0.5	0.3	0.3	0.4

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

Table B.70 Area Eroded in 1987 by Reach and Char Type (Hectares)

River Reach	Unprotd Mainland South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	0	0	0	21	0	21	21
Middle	0	0	0	0	0	0	0	0
Lower	2	1	0	0	0	1	2	3
Total	2	1	0	0	21	1	23	24

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 South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	49	89	0	183	49	183	321
Middle	0	0	0	0	0	0	0	0
Lower	2	2	0	0	0	2	2	4
Total	2	51	89	0	183	51	185	325

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 South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	142	428	6	407	147	407	982
Middle	0	0	0	0	10	0	10	10
Lower	3	3	0	0	0	3	3	6
Total	3	145	428	6	417	151	420	999

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 South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	0	0	0	28	0	28	28
Middle	0	0	0	0	0	0	0	0
Lower	8	4	0	0	0	4	8	12
Total	8	4	0	0	28	4	36	40

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 South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	9	32	0	238	9	238	279
Middle	0	0	0	0	0	0	0	0
Lower	15	10	0	0	0	10	15	25
Total	15	19	32	0	238	19	253	304

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 South	Attached South	Island Char	Attached North	Unprotd Mainland North	Sub Total Attached	Sub Total Unprotd Mainland	Total
Upper	0	63	407	0	649	63	649	1119
Middle	0	0	0	0	6	0	6	6
Lower	29	20	0	0	0	20	29	49
Total	29	83	407	0	655	83	684	1174

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