Chapter 6
The Controlled Lower Damodar River: A Social Perspective

Abstract The Damodar riverbed consists of a series of alluvial bars that are now used as a resource base mostly by refugees. The stretch between Panchet Maithon reservoirs and Barsul-Chanchai is not atypical in terms of contemporary riverbed morphology and bed materials particularly below the Durgapur barrage. But the riverbed landscape, formed by interactions between the riverbed and its occupiers, shows diversity at a micro level. Using their knowledge of river stages, settlers have matched land use at fine scales to flood incidence, applying a concept of flood zoning to the riverbed and effectively utilizing every available inch of space. Functional relations between the riverine environment and riparian community have been influenced by culture, social space, perceived environment, land ownership rights and political forces. As there is no a priori model for human-environment relations, assessment of short-term risks and long-term benefits of water release from the reservoirs and decisions on specific land use are made on the basis of personal experience. The stretch between Maithon/Panchet reservoirs and Barsul Chanchai has become less hazardous and more resource-rich with the mitigation of the annual flood discharge. Here risk is capitalized as resource and long term benefits have overshadowed the short term risk. Paikpara is an example of changing location of the resource base subsequent to a geomorphic threshold. The opening of the Muchi-Begua Hana has transformed an over-bank settlement to a mid-channel settlement. The thalweg of the Amta Channel is extremely narrow compared to the culturally defined riverbed and is not so significant in comparison to the other two sectors of the Lower Damodar.

Keywords Flood-zoning · Functional relations · Indigenous techniques · Land-use · Perception · Resource base

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6.1 Understanding Human Role in Changing Riverine Environment

While examining the applied geomorphological issues of the Lower Damodar, the focus was on floods, flood control measures, and the impact of control structures on selected hydro-geomorphic parameters. Geomorphic forms, processes and materials between control structures, lateral or transverse, were considered quasi-natural but fundamental entities and were explained accordingly. In the present section, the controlled riverbed will be assessed from a land use and social perspective since a large portion of the riverbed is intensively used by Bangladeshi refugees who have colonized the riverbed in phases. They have taken an active role here in changing the riverine environment through land utilization. The occupiers have built up a functional relationship with the riverbed. Land use in the riverbed bears the imprint of the functional relationship between the riverbed and its occupiers. As a result, the forms, processes and materials in the riverbed are no longer fundamental entities but deserve functional identity. This does not necessarily imply that land use characteristics are totally governed by riverbed characteristics of the controlled sector. People's culture, perceptual capacity to assess an environment and position in society also play a decisive role in decision-making regarding specific land use. Ownership of land, demand and market forces are also significant factors behind land use decisions (Bhattacharyya 1998, 2002, 2009).

It has been accepted now that cultural elements such as settlements, agricultural fields, roads and railways are viable components and effective indicators of a dynamic geomorphic landscape. One may still argue that different artifacts are nothing but mere components of cultural landscape. The validity of this statement is not questioned but is worth further consideration. A cultural landscape results from human intervention with the physical landscape through specific culture and, ultimately, components of the inherited physical landscape become inseparable from the superposed components of cultural landscape. V. R. Savage (1992) has traced the changing landscape of Singapore with the changing of land use. His article has been included in "Physical Adjustments in a Changing Landscape" edited by Gupta and Pitts (1992). Land utilization in the Damodar riverine sandbars has been treated as an anthropogenic geomorphic process and the emergent landscape as a product of twin processes, hydro-geomorphic and anthropogenic. Factors that play into riverbed land use include tension between host communities and the migrants over a shared resource base and the fact that an active river remains flood-prone despite flood control measures.

River training is an anthropogenic process but this process has to function within the limits of natural laws. In land utilization processes, however, non-physical laws and norms have to be acknowledged to a greater extent together with physical forces. Cultural heritage, socio-economic situations, and technological levels are the significant factors in rural land use. Variations in physical aspects bring explainable changes in land use under similar geomorphic processes and other correlated environmental parameters (Verstappen 1983). But unlike physical laws, social or economic laws and norms are not universal but location- and

culture-specific. Applied geomorphological issues are also location specific (Pitty 1982; Bhattacharyya 1998). Therefore, in the analysis of land use, the method has to be ideographic.

The spatial range considered in this study is the riverbed between and/or below control structures on the river Damodar. Almost all riverine bars have been considered between Panchet and Maithon reservoir and the Falta outfall for land use analysis. The whole stretch has been divided into three sectors. Sector one extends between the reservoirs (Maithon and Panchet) and Barsul-Chanchai village, where the Lower Damodar takes a southerly course. Sector two stretches up to Paikpara settlement below, where the Damodar starts distributing its major part of discharge through the Kanki-Mundeswari. The Amta channel has been treated separately. The time span of the study is from 1990 to 2008 in assessing human perception, adaptability, land-use characteristics, and evaluating resources in the riverbed. The background of the present land use, however, has been traced from 1854 since the Dickens's map has been used as a base map for this purpose.

In examining riverbed land use in the Lower Damodar, hydro-geomorphic data from previous sections have been used and conclusions of the previous sections are the foundation blocks on which the basic structure of arguments for and against contemporary land use has been built for the present chapter.

The technique adopted is the field survey technique. The perception survey technique has also been applied to assess people's views on the control structures, consequent hydro-geomorphic changes, resource potential of alluvial bars and hazard risks in between control structures. Interpretation of a series of cadastral maps, SOI (Survey of India) maps, geocoded maps, and satellite images is the geographic technique and this technique has been applied to generate qualified data to be incorporated with active field data and hydro-geomorphological data for appraisal of land use. Tools include SOI maps, cadastral or mouza (a land-settlement division of an area) maps, the 1994 Satellite Image (IRS-IB LISS-2/FCC/classified image, 1:100,000) and IRS Geocoded Imagery of 1992 and 1999 (1:50,000) and 2003 LISS-3 scenes of an IRS-ID satellite (Appendix A). Some sociological, anthropological and economic and geographic concepts like social space, culture, perception, resource, human ecology, hazard, political economy, empiricism etc., will be considered while examining the land use characteristics. Like any other applied discipline, applied geomorphology also takes an interdisciplinary approach, and therefore can borrow relevant concepts from other disciplines.

Land use data has been collected from repeated field visits. I have had to depend on active data since rural land record offices maintain land use data only for legally owned land. In my study area, the refugees have either not yet obtained "patta" or land deeds, or they have only been granted land deeds in the riverine alluvial bars very recently. Therefore, the BDO or Panchayet, BLRO or similar institutions do not have complete sets of land use data. Most of the Bangladeshi refugees have been granted land deeds. They were very much apprehensive about the research objectives and were initially reluctant to provide data on land area and crop production.

Colonized people were surveyed in groups and individually. The first reconnaissance survey and actual survey started in 1990 and 1993 respectively and was completed in 1997 with follow-up surveys conducted in 2000, 2001, 2007, and 2008. The total number of sandbars surveyed in the Damodar River is 23. Each sandbar consists of several mouzas that include 91 villages. The total population of these sandbars is 50,000 approximately and 1% of them were surveyed initially using the model questionnaire.

The main questions addressed are given in the survey questionnaire (Appendix H), and some of their answers in Bengali language are as follows:

1. Can you assess how much area will be inundated if water is released from the reservoirs?

We estimate accurately that peripheral areas of sandbars get inundated with discharge exceeding 4,248 m^3/s, multiple crop areas are flooded with discharge exceeding 5,664 m^3/s, and we need to take shelter on the highest part of the Bara Mana situated within northeastern part of the Pakhanna-Bhairabpur mouza with streamflow exceeding 7,080 m^3/s.

"Amra jodi sathik vabe hisheb kori tahole dekhbo 1.5 lukh cusec er beshi jal charlei balicharer prantobhag bheshe jabe, 2 lukh cusec er beshi jal charle bibidho shasya utpadaner khetragulo o bheshe jabe, ar jodi 2.5 lukh cusec er beshi jal chhare amader Pakhhnna – Bhairabpur mouzar uttarpurbo dike bara manar sabcheye unchu jaygay giye ashray nite hoy" said Prakash Biswas, a farmer of Bara Mana.

1. What is your experience when water is released from the reservoirs?

Release of water from reservoirs has initiated bank erosion and we are constructing a series of dykes to fight against bank erosion.

"Nadirparer kshoy shuru hoy jaladhar theke jal chara thekei ar amra ai parer kshoy rodh koear jonno band her par bandh banie cholechi" said Binod Das, a well-known farmer, who took initiative for planning and constructing a series of dykes in Rangamatia.

I also asked several questions as follows:

i. Can riverbed occupiers perceive hydro-geomorphological consequences of control structures?
ii. Are they aware of regular or sudden release of water from reservoir, barrage, and weirs?
iii. What are the indicators selected by them for assessment of resource potentialities of the riverbed?
iv. What are the measures taken during flood years, or if there is a threat from sudden release of water or bank erosion?
v. Are the Bangladeshi migrant communities aware of their refugee status? Does that influence their decision on land use?
vi. Is there any difference in land use between locals and non-locals, particularly between local Bengalis and Bangladeshi refugees?
vii. Is there any political pressure on the refugees regarding land use?

6.2 Contemporary Riverbed Characteristics Between the Maithon Panchet Reservoirs and Barsul-Chanchai

The Lower Damodar between the reservoirs and the Barsul-Chanchai settlements flows through two disparate phases. Right up to Raniganj, the most important colliery town in the district of Barddhaman, the riverbed and bank are characterized by the features of a bedrock-controlled river. Just below the reservoir, there is a rocky exposure. Similar rock outcrops are to be observed near Dhanua, Bakulia, Babjadanga, and Amkula above Raniganj. The exposed rocks belong to the Gondwana Sedimentaries. Height of the river bank varies between 6 and 10 m between the reservoir and the Radhanagore railway station near Sitarampur. Below Raniganj, the Lower Damodar bed is an alluvial controlled riverbed. The river bank height varies between 2 and 4 m except in a few places. Below Barddhaman, river bank height exceeds 4 m only for a small section. In the bedrock-controlled sector there are several bars of differential locations, shapes and dimensions. Bar materials are usually coarse sand together with fragmented sandstone, shale and coal. Below Raniganj, the riverine bars change their characteristics with the changes becoming more noticeable below the Durgapur barrage. Several longitudinal bars, either mid-channel or marginal, are observed below the barrage. The bar materials become finer and are usually sandy loam, loam or clay. Between the reservoirs and the Durgapur barrage, the Lower Damodar is deep enough for all-season ferry services. But below the Durgapur barrage ferry service is restricted to the monsoon season only and the river is fordable in the non-monsoon period (Plate 6.1).

Major left and right bank tributaries are the Harial, Nunia, Singarani, Tamla, and Kukua on the left, and Machkanda, Beharinath, Bangarpur, Ghaighata, Chouphari, Barajuri, Barjara, and Sali on the right. These tributaries flow through erosion-prone deforested tracts in the Raniganj coalfield and soil-covered Purulia and Bankura districts and contribute an enormous amount of sediment to the Damodar above Silna. Of these tributaries, the Sali on the right and the Nunia nala on the left need special mention. During the 1978 floods, the Sali was almost choked with sediment in its middle and lower sectors and contributed enormous amounts of sediment to the Damodar River. The riverbed sediments are also derived from sheet wash, particularly in colliery areas where soil has been loosened due to mine blasting. Coal spoils contribute sediment to the riverbed through sheet wash and gully erosion as well. The shallow riverbed below the Durgapur barrage is dotted with several semi-stationary and stationary alluvial bars. There are several spill channels or *hanas* to be observed in this area. These have been mentioned in the previous section. Khari and Banka were two important distributaries in the historical past but have now been severed from the main river due to construction of roads, railway lines and embankments.

Above Raniganj, Gangtikali is the only settlement in a riverine bar. The number of riverbed settlements increases below Raniganj and multiplies below the Durgapur barrage right up to Barddhaman. Between Majher Char and Barsul-Chanchai, the river narrows down and the number of alluvial bars decreases. From a riverbed utilization point of view, the section between the Durgapur barrage and the Jujuti sluice is the most significant. There are several settled and few partially settled

sandbars between Maithon Panchet reservoirs and Paikpara village. All of these sandbars have been considered in reviewing generalized land use characteristics and the resultant landscape through human intervention.

6.3 Land Use Planning in the Riverbed: Maithon Panchet Reservoirs to Barsul Chanchai

The three sectors of the Damodar between the Panchet and Maithon reservoir and the Falta outfall mentioned previously will be discussed in turn in the following sections. Each riverine bar selected for reviewing land use characteristics will be discussed in detail. For each bar, locational characteristics, hydro-geomorphological phenomena and population characteristics will be considered prior to the discussion on land use. The stretch between the Panchet and Maithon reservoir and Barsul-Chanchai village is subdivided into three sections. The first section is from the Panchet and Maithon reservoir to the Durgapur barrage, the second section is up to the Jujuti sluice and the third section is up to Barsul-Chanchai village where the river takes a sharp turn. This sub-division is based on riverbed and land use characteristics.

6.3.1 Gangtikali

Gangtikali or Gang Tikli means a head ornament in a river. Gang means a river or a stream. Tikli is a head ornament used at the center of the forehead. Gangtikali is an oval shaped rocky island that looks like this head ornament. It is a part of the Raniganj coalfield and is sited just below the confluence of the Damodar with the Barakar. It is located southwest of Asansol, an important urban industrial centre of West Bengal. Gantikali is a part of the Saltora mouza, and is under the police station of Nituria of Purulia district (Fig. 6.1). The nearest railway station is Kulti.

On the Barakar side, Gondwana sandstone, shale and coal seams have been exposed. Some spectacular potholes carved in sandstone are noticeable features of this side which also contains a series of flood-built terraces. Lower terraces are formed of sandy materials with an abundance of quartz and feldspar particles. This rocky island is bounded by a 100 m high contour. The maximum height is 120 m. Although bounded by the Damodar on the south and east and by the Barakar on the West and North, Gangtikali was never flood-prone because of higher elevation. Flood risk has been further reduced due to the Panchet and Maithon dam closures. Due to reduction in monsoon discharge and peak discharge as well, the main settlement and the agricultural fields remain much above the water level for a greater part of the year. Except for the thalweg, both rivers are almost fordable in the dry months.

The total population of Gantikali is approximately 225. There are 50 families. Bihari Kuris, an agricultural caste from the Chhotanagpur, migrated to Gangtikali with the opening of the coal mines. The Gangtikali settlement predates major control

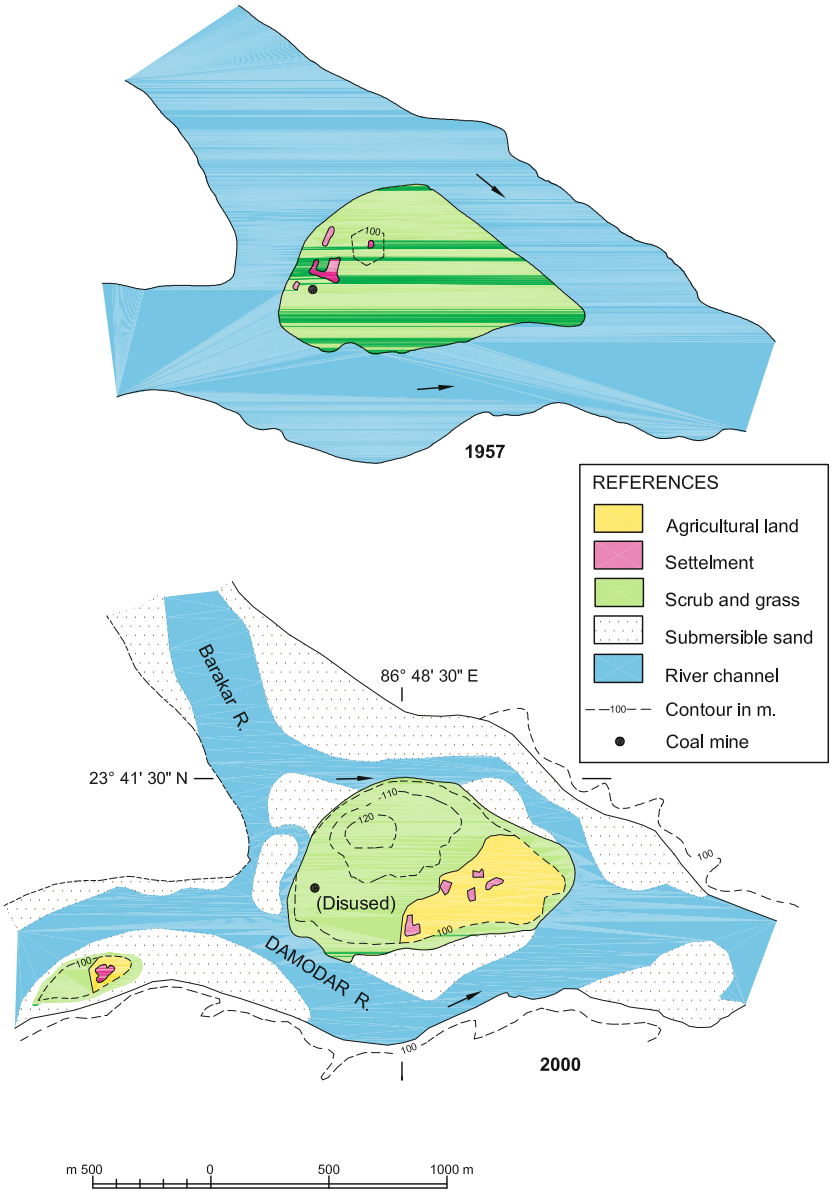

Fig. 6.1 Changing cultural landscape of Gangtikali
Map prepared through active field survey and using several Survey of India (SOI) maps of 73I/10, (1:63,360, 1:50,000). Cadastral map of Saltora is consulted

structures and the contemporary land use and landscape can only be explained if land use characteristics of the early part of the present century are considered. In fact, land use in Gangtikali shows three distinct phases: pre-coal mining, coal mining and post-coal mining. In the pre-coal mining phase Gangtikali was an unpopulated forest-covered island. The forest, therefore, did not have any functional entity and was just one of the components of the natural landscape. With the opening of coal mines in the early part of the twentieth century, organized land utilization started and coal became the main fund resource. Forests were cleared and over burdens were blasted off. Removal of solids from the surface created depressions that were later filled up with water. There were other significant changes in landscape. With the heaves of coal spoils, relief variations were accentuated at a micro level. Noticeable changes also occurred in floristic composition, as forest vegetation degraded to xerophytes scrub vegetation.

The flood of 1958–1959 can be treated as a threshold in the land utilization history of Gangtikali. Mines were flooded and mining activity ceased to be economically viable. At this juncture, agricultural resource potentialities were harnessed in the eastern part of the rocky island. As the islanders are mostly from Bihar, their preferred food crops, wheat and maize, are the main crops grown. There are also guava plantations.

Because of higher elevation from the riverbed, lift irrigation poses a problem. Therefore, release of water from the Panchet/Maithon is perceived as a viable resource and is always welcome. In the coal mining phase, the main settlement was on the northwest of Gangtikali as is evidenced from the SOI map of 1929–1930 and the geological map (1951–1952) of the Raniganj coal field. The present settlement is on the southeastern part of the island. In Gangtikali, changes in cultural landscape are very much prominent (Fig. 6.1). The contemporary landscape consists of two units, the abandoned colliery with coal spoils and depressions, and xerophytic bushes and the agricultural fields with settlements.

6.3.2 Vivekanandapalli Squatters' Colony

The very name of this settlement suggests that it is a colony of displaced people. The settlement is named after Vivekananda, a notable Bengali religious figure. Popularly known as Telenda Mana, this settlement is sited on a marginal bar and situated upstream of the Durgapur barrage. The alluvial bar is a part of the Telenda and Mejia mouzas under the police station of Mejia, Bankura district. The closest large settlements are the Mejia thermal power station and Andal, the biggest railway yard in India.

The alluvial bar is bounded to the north by the Damodar and to the south by the Gaighata Jhor. Despite being situated between a reservoir and a barrage, Telenda Mana is not usually flooded when water is released from the reservoirs since the main flow of the Damodar is away from the settled bar. On rare occasions, there may be backrush from the barrage and the bar gets flooded by the Gaighata and Damodar as well. Sands are the dominant surface materials.

The Telenda Mejia Mana settlement is a refugee settlement. In the portion of the sandbar under the Telenda mouza there are 28 families and 32 households with a total population of about 225. In the portion of the sand bar under the Mejia mouza there are only about 9 families with a total population of 50. Prior to human habitation, almost the entire sandbar was covered with jungles and wild grasses. Scrubs and grasses are still seen in some areas, however, most of the grasses have been cleared since Bangladeshi refugees started colonizing the bar in 1956.

Wet rice and jute were introduced to Telenda Mejia Mana by Bangladeshi refugees as major cereal and cash crops. Both crops are part and parcel of agriculture in the Bengal delta but jute was not an important cash crop in this part of Bankura. With the application of fertilizers, nutrient status of the soil has improved. In addition to rice and jute, wheat and potato are grown as spring crops. Fast-growing vegetables and fruits such as cucumber and watermelons are grown with the lowering of river water level on the margin of Telenda Mana. These *zaid*, or additional crops, are sown in February and March and harvested in summer.

Though the marginal bar is not very inundation-prone, agricultural plots are aligned transverse to the Damodar and the Gaighata jhor so as to avoid disaster from floods in unusual years. The riverbed of the Gaighata jhor is used for additional crops (Fig. 6.2). As the main flow of the Damodar is away from the agricultural fields, the Gaighata jhor is perceived and treated as the main source of irrigation. At present almost all households have tube well facilities.

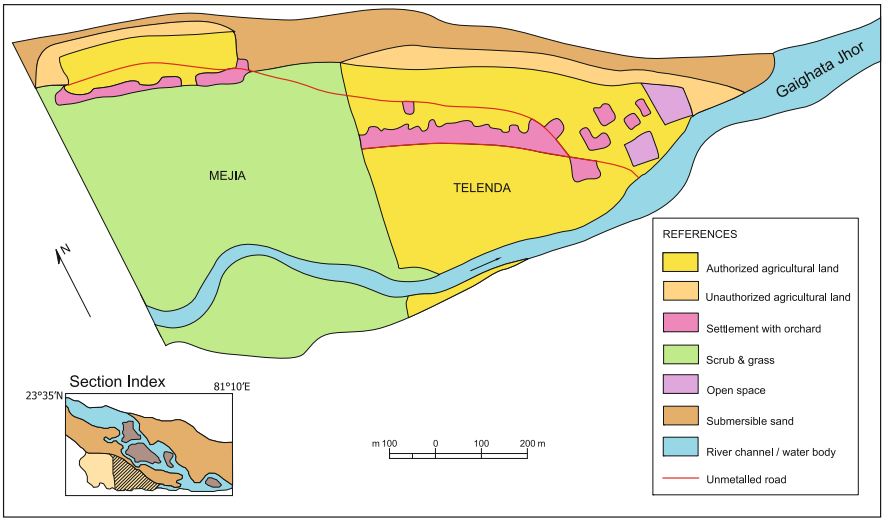

Fig. 6.2 Vivekananda Palli Squatters' colony: land use characteristics
Map prepared through active field survey and using several layout plans (Cadastral maps of Telenda and Mejia) originally prepared between 1994 and 1995 and modified between 2007 and 2008 with active support from Refugee Relief and Rehabilitation Department (RR&RD), Bankura, Govt. of West Bengal

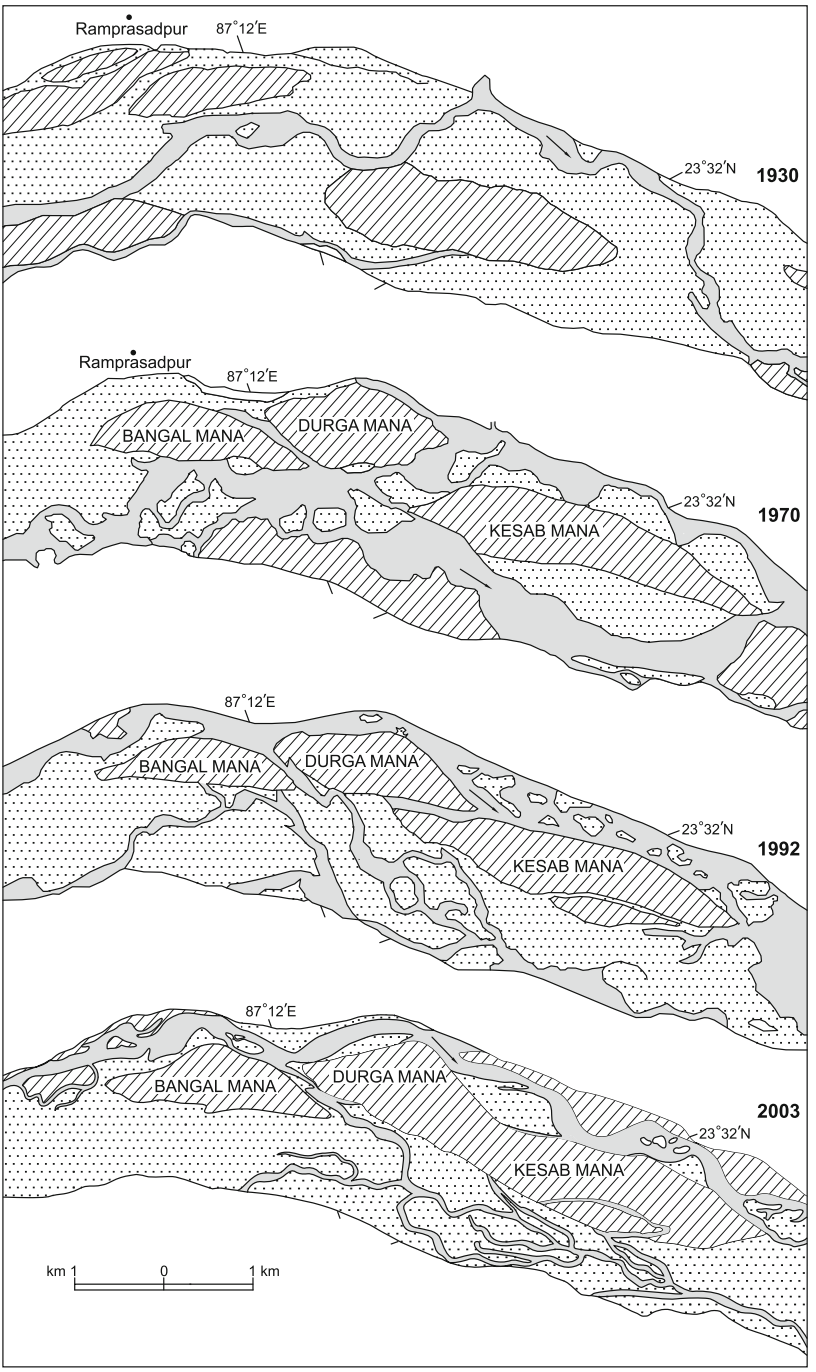

Fig. 6.3 (continued)

The settlements are mostly on the highest part of the bar although flood risk is very low in Telenda Mana in general. A new settlement, Mejia Mana, known as new Vivekananda Colony, has developed towards the Panchet. This is away from the Gaighata jhor and sited towards the northern bank of the Damodar. Both the settlements are linear in pattern.

6.3.3 Damodar Char Mohana

The Damodar Char Mohana colony consists of Bangal Mana, Keshab Mana and Durga Mana. All types of bars are referred to as *Char* in Bengali. In Bangladesh Chars are locally known as *Mana* derived from *Mohana* which usually denotes a confluence of river and sea. Erstwhile East Bengalis and the present Bangladeshis are often referred to as *Bangal* in West Bengal. Since Keshab and Durga are names of a Hindu god and a goddess, the very names of the settled sandbars indicate that the settlers are Bangladeshi Hindus. Damodar Char Mohana colony is sited upstream of the Durgapur barrage in the police station of Mejia of the district of Bankura. These sandbars consist of portions of five mouzas: Balarampur, Damodar Mohana, Debagram, Purbator and Dighal Gram.

These sandbars are elongated. The SOI map of 1929–1930 shows this alluvial bar as several small bars in a braided channel covered with grasses but the SOI map of 1969–1970, IRS Geo-coded imagery of 1992 and 2003 LISS-3 scenes of IRS-1D satellite show the bar as a more or less continuous one. Bar materials vary from fine sands to coarse sands. Although fragmented bars have merged with each other, some of the decaying channels can still be seen in the Damodar Char Mohana colony. The depth of the water table is 12 m. Since the area is situated between the reservoirs and a barrage, the risk of inundation is very high. Monsoon inundation risk has decreased after the construction of the Maithon and Panchet reservoirs. Apart from inundation, proximity to the barrage makes the settlement vulnerable to backrush of water from the barrage. Also, extraction of sands by coal boats on the left bank has deepened the channel and the Geo-coded map of 1992 show severe bank erosion and size reduction of these bars (Fig. 6.3). These sandbars are merging together as is evident from the 2003 LISS-3 scenes of IRS-1D satellite image.

Fig. 6.3 Changing river bed morphology: Damodar Char Mohana
The maps drawn from the Survey of India (SOI) maps (73 M/2, 1: 63,360, 1: 50,000), Geocoded Imagery of 1992 (1:50,000) and 2003 LISS-3 scenes of IRS-ID satellite are shown. The maps show changes in the river between 1930 and 2003. In 1930 the river occupied a portion of the area divided by unvegetated bars. In 1970 the stream flow had been divided by vegetated bars. People have occupied these sandbars. In 1992 the right bank flow was diminished and the river looks narrower than in former times. In 2003, the sand bars were getting enlarged. Planform evolution has been shown using a sequence of pictures rather than by superposition because the braided and anastomizing patterns would create a very confusing image

Bangal Mana and Kesab Mana are both refugee-dominated sandbars, whereas Durga Mana is a Bihari dominated village. There are about 180 families with a total of more than 1,500 people. Land use in these bars is finely adjusted with inundation risk. If the duration of floods is short, the current is mild, and silt deposition is rich, the prospect of a bumper harvest is very high. On the other hand, if the flood retreat phase aggravates bank erosion and scouring of the riverbed, utilization of the riverbed is hampered. The floods of 1978, 1995, 2000, and 2007 have done extensive damage to the Damodar Char Mohana colony. Two crops are usually grown every year on these bars. *Kharif* crops are sown after the first shower of monsoon and are harvested after the last spell of monsoon. *Rabi* crops are winter crops that are sown in the autumn and harvested in the spring. If there is flooding on the bar due to excess release of water from the Panchet, sowing of Rabi crops may be delayed. An additional crop, or *zaid*, is also grown on the periphery of the alluvial bar when water level falls and fresh sand deposits are exposed. Kharif crops include rice, pulses, groundnuts, fruits, and vegetables. Rabi crops grown in the bar are rice, wheat, oil seeds, pulses and vegetables.

Wheat is the preferred crop of Bihari families in Damodar Char Mohana. The Bengalis also cultivate wheat as there is a ready market for this crop. Potato cultivation requires continuous vigil, repeated watering at least five to six times a day and several weeding operations. Potato is grown in sandy loam but in the vicinity of settlements. Chilli is a major cash crop in the district of 24-Parganas (South), and the Bangladeshi refugees have introduced chilli as an important cash crop to this bar. The first crops grown on this bar were cucumber, watermelon, bitter gourd and long melon that were planted on fresh sands which are believed to be of low nutrient status. These are zaid, or additional crops. Perennial grasses are allowed to grow on banks that are erosion-prone due to high inundation. These grasslands are carefully maintained.

Pronounced relief variations cannot be expected in an alluvial bar. But relief variations at the micro level can be identified from observations of the cultural landscape. Settlements and perennial tree crops indicate inundation-free higher elevation. Settlements in the Damodar Char Mohana are sited on the highest elevation, and individual houses are constructed on higher plinths above the usual inundation level. The settlers were thus not much affected in the flood years of 1958, 1959, and 1971. The floods of 1978, 1995, 2000, and 2007, however, caused some damage to the houses on the bar. The settlements are dotted with perennial crops such as mango and jackfruit. The zone below the highest elevations is devoted to the cultivation of cereals and important cash crops. Inundation-prone low-lying areas are left for inferior types of vegetables and fruit crops mentioned above. The cultural landscape of the Damodar Char Mohana thus exemplifies the concept of flood zoning. Spatio-temporal extension of individual zones varies from year to year due to spatio-temporal variations in release of water from the Panchet and Maithon reservoir. Riverbed sands are extracted by coal boats for sand stowing in the collieries of the Ranigunj. As a consequence, the inactive riverbed on the left side has been deepened and this has posed a threat to the stability of the bar.

Colonization in the Damodar Char Mohana started rather late because of its high inundation risk. From 1956 onwards the Bangladeshi refugees started occupying this riverine bar. Now they have been granted land deeds, although the DVC authority does not like the idea of permanent settlements in such a vulnerable riverbed. Dried up channels are used as village roads and are important components of land use. There was a school but the school building was demolished during the 1995 floods and had to be reconstructed.

6.3.4 Ramakrishna Palli, Pallishri and Sitarampur Mana

The Ramakrishna Palli, Pallishri Sqatters' colony, and Sitarampur Mana are sited on a marginal sandbar and the first two are separated by a narrow dried-up channel. These sandbars are situated below the Durgapur barrage within the Barjora police station of the Bankura district and comprise parts of Paharpur, Krishnanagore, and Bamandihi mouzas. The settlements have been named after Ramkrishna, a Hindu religious figure, and Sita and Ram, epic characters of the Ramayana. Palli means a village and Shri means beauty. Pallishri used to be a squatters' colony but the residents have now been granted land deeds.

Rivers are natural boundaries and are often taken as demarcating lines between countries, states and districts. Political boundaries change over time but usually remain static within a short time horizon. Although bedrock-controlled rivers are usually fixed in their position within graded time, alluvial channels in their low gradient sectors keep on changing their positions within the same graded time frame. Braided and meandering channels, in particular, often shift as a consequence of channel adjustment with discharge, load and gradient, often shifting far away from the political boundary. The political boundaries thus help in identifying the shifting nature of a river.

In this part of the study area, the Damodar used to define the administrative boundary between the districts of Barddhaman and Bankura. The cadastral map of 1957 shows this sandbar as existing within a channel riverine bar. But in 1996 the bar appeared to be a part of the mainland as the main Damodar has shifted far south of its previous position.

The Cadastral map of 1957 (Fig. 6.4) shows:

i. A wide Damodar main channel (D1)
ii. A narrow channel between two bars (D3)
iii. A very narrow meandering channel towards the district boundary (D2)

By 2003–2007, however, the map (Fig. 6.5) shows

i. The main Damodar (D1) has become very narrow on the right side, as a big sandbar, though transient in nature, has emerged
ii. The previous channel separating two bars has become a feeble channel (D3)
iii. A narrow channel (D2) towards the district boundary can still be observed

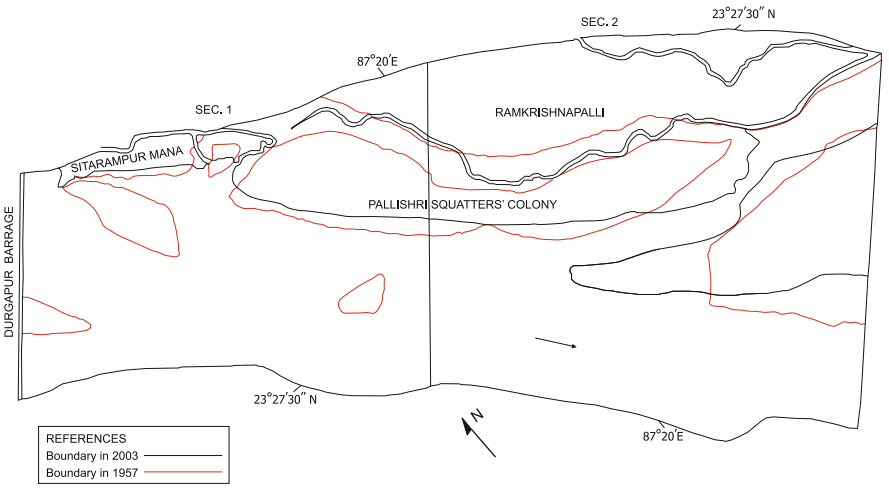

Fig. 6.4 Changing boundary of Sitarampur Mana, Ramkrishna palli and Pallishri squatters' colony Maps prepared from cadastral maps (Paharpur, Krishnanagore, and Bamandihi), 2003 LISS-3 scenes of an IRS-ID satellite from Indian National Remote Sensing Agency (NRSA), Hyderabad and layout plans prepared between 1994 and 1995 and modified in 2007 and 2008

iv. There is an ill-defined channel (D4) separating the transient sandbar and the settled sandbar of the Ramkrishnapalli and Pallishri colonies
v. There is another feeble channel (D5) north of the Sitarampur Mana.

Due to controlled release of water from the reservoirs and the presence of a sandbar just below the settled bar, inundation risk is usually low in this area. The ill-defined channel (D4) gets activated when there is excess release of water from the reservoirs. The 1978 floods inundated the entire bar and caused damage by riverbed scouring but did not totally destroy the bar. The flood of 1995 also did damage but only for a few hours since the barrage started releasing water at midnight on 29th September 1995 and the release of water continued for 10 h. The flood of 2007 also did damage when the barrage started releasing water on 25 September.

The Ramakrishna Palli, Pallishri, and Sitarampur Mana bar is settled by Bangladeshi Hindu refugees. Changes in generalized land use characteristics and landscape are shown (Fig. 6.5). The bar material varies from fresh sand to clay, and these clay deposits are to be found on the beds of D2, D3, and D4. In the dried-up portion of D3 the river bed is used for double cropping (Figs. 6.6 and 6.7). Clay deposits of the dried up channel are good for rice culture (Plate 6.2). This indicates that the people can perceive deposition of clay materials in decaying channels and the higher field capacity of clay soil. Residents can assess the resource potentialities of the sandbars.

Multiple cropping is a common practice in this alluvial bar. Additional crops are grown on the bed of D4 and in areas adjacent to it. These are unauthorized agricultural fields. There is a small sandbar between Bara Mana and these bars, but

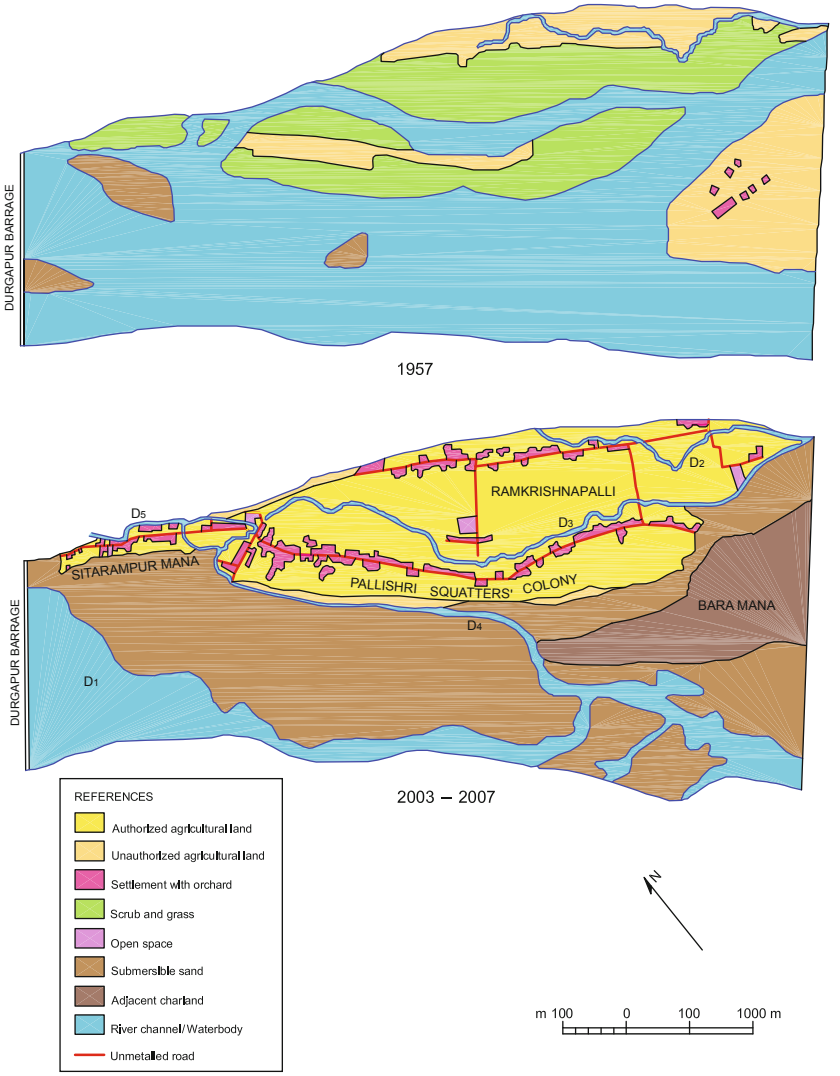

Fig. 6.5 Sitarampur Mana, Ramkrishna palli and Pallishri Squatters' colony: changes in generalized land use characteristics and landscape
Map prepared from cadastral maps (Paharpur, Krishnanagore, and Bamandih), Survey of India (SOI) maps of 73 M/7 N.W (1:25,000), 73 M/7 (1:50,000), 2003 LISS-3 scenes of IRS-ID and layout plans prepared between 1995 and 1997 and modified between 2007 and 2008

this small bar has merged with Bara Mana. This bar is also extensively cultivated but there are no settlements on it as residents perceive this sandbar as vulnerable to inundation when channel D4 becomes reactivated (Fig. 6.5). Almost all types of vegetables, oilseeds, and cereals are grown here. Comparatively infertile lands are used for cultivation of a coarse variety of jute (Mesta). Oilseeds grown in this sandbar are

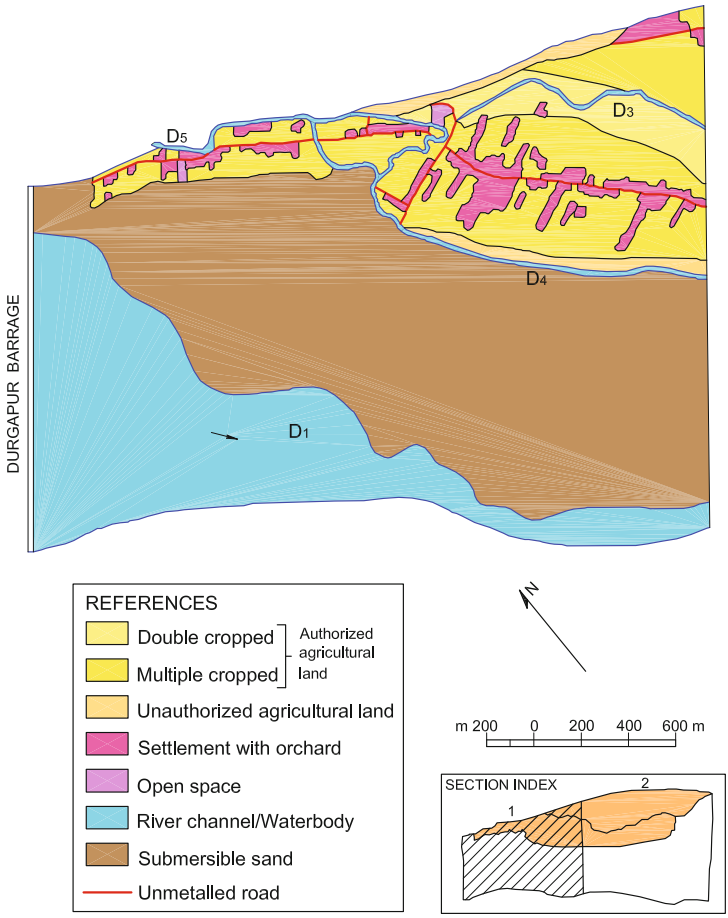

Fig. 6.6 Sitarampur Mana, Ramkrishna palli and Pallishri Squatters colony (Section-1): land use characteristics
Map prepared through active field survey

mustard and sesame. Cereals like rice and wheat are also grown here. Many types of vegetables such as pointed gourd (*T. dioica*), potato, bringal (*Solanum melongena*), and Chilli (*Capsicum frutescens*) as well as winter vegetables such as pea (*pisum sativum*), cauliflower, and cabbage are grown here. The Figs. 6.5, 6.6 and 6.7 show hydro-geomorphological characteristics and land use features that include the channels of D1–D5. The emergence of new sandbars and areas of double and multiple cropping are visible. The main Pallishri settlement is located away from the channel D1 at a higher elevation. This part of Pallishri, incidentally, has been the most stable part of the sandbar since 1957. Ramkrishnapalli is located close to the district boundary. The Sitarampur Mana is an extension of the Pallishri colony. Village roads are almost parallel to each other. In fact, village roads follow the boundary line between agricultural plots, particularly towards the southwestern part of Pallishri. These series of small village roads have not been shown (Fig. 6.6).

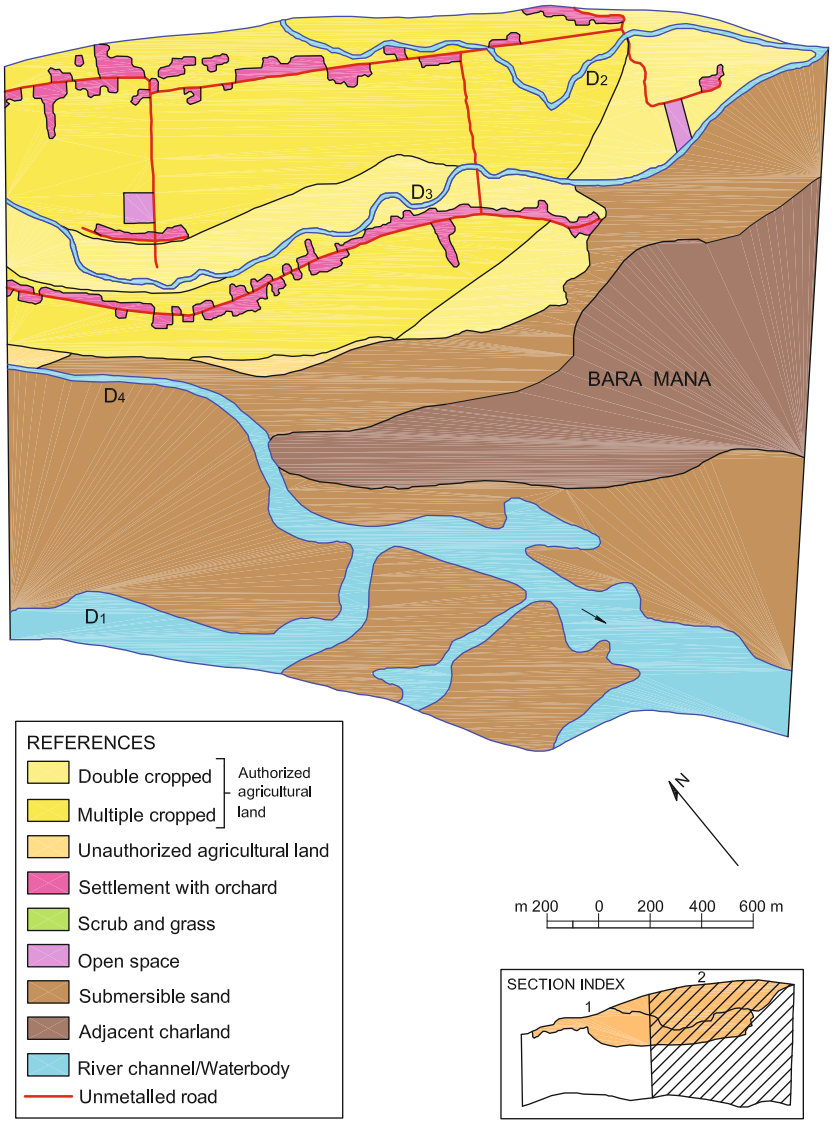

Fig. 6.7 Sitarampur Mana, Ramkrishna palli and Pallishri Squatters colony (Section-2): land use characteristics
Map prepared through active field survey

6.3.5 Bara Mana

Bara Mana, the largest alluvial sand bar in the culturally defined Lower Damodar, is sited below the Durgapur barrage. The Chhota Mana, located in the extreme western side under Bamandihi mouza, and the Saha Mana, located within Pakhanna–Bhairabpur mouza, are included within this bar. Bara Mana is part of

eleven mouza maps or villages. They are Bamandihi, Purakonda, Tajpur, Pakhanna Bhairabpur, Pakhanna, Radhakantapur and Gopalpur under Barjora Police Station and Palashdanga, Jaynagar, Alampur and Dihipara under Sonamukhi police station of the Bankura district. The total area of Bara Mana is approximately 11 km^2. Durgapur and Panagarh are the nearest towns and railway stations towards the Barddhaman side. They are approachable by ferry service from Pakhanna in the district of Bankura. Bara Mana is an elongated mid-channel bar with a maximum length and width of 11 and 1.5 km respectively. The highest elevation is 62 m (above mean sea level now in Karachi, Pakistan).

The evolutionary history of Bara Mana has been traced using mouza maps of three series: Cadastral survey (CS) maps, surveyed between 1917 and 1921, Revision Survey (RS) maps surveyed between 1954 and 1957, and Layout plans surveyed between 1994 and 1997 (unpublished), SOI maps 73 M/7 surveyed between 1969 and 1985 (1:50,000, 1:25,000), and the 2003 LISS-3 scenes of the IRS-1D satellite. For detailed analysis, the Bara Mana has been divided into six sections taking mouza boundaries as lines of demarcation. Mouza boundaries follow straight lines at the riverbed and small mouzas have been treated together or included with larger ones. In 1921 there were two sand bars. By 1957, the bars had merged together to form an elongated bar (Fig. 6.8). In later years this alluvial bar has been truncated

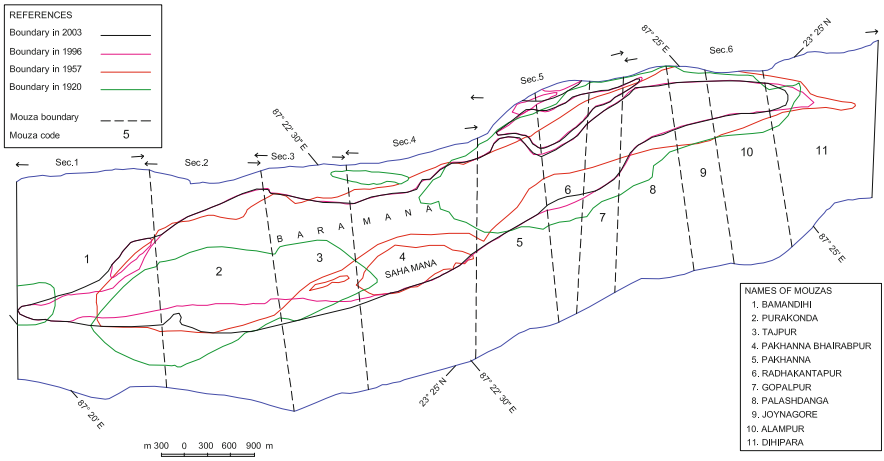

Fig. 6.8 Changing boundary of Bara Mana
Maps prepared from cadastral maps, SOI maps, and 2003 LISS-3 scenes of IRS-ID satellite.

Cadastral Survey (CS) maps (Bamandihi, Purakonda, Tajpur, Pakhanna Bhairabpur, Pakhanna, Radhakantapur, Gopalpur under Barjora Police Station and Palashdanga, Jaynagar, Alampur and Dihipara under Sonamukhi police station of the Bankura district), surveyed between 1917 and 1924, and Revision Survey (RS) maps surveyed between 1954 and 1957 and several layout plans originally prepared between 1996 and 1997 and modified between 2007 and 2008, have been used.

Survey of India (SOI) maps of 73 M/7 N.E., 73 M/7 N.W., 73 M/7S.E. (1:25,000), 73 M/7 (1:63,360, 1:50,000), IRS Geo-coded imagery 73 M/7, satellite image of 1994 IRS IB LISS-2 FCC classified image 1:100,000 have been consulted

and elongated at the western end. At some places in the eastern and western sectors Bara Mana is very narrow. Since 1957, the Saha Mana situated below section 4 appears to be a stable bar. It is separated from the main alluvial bar by a feeble channel which is almost choked with sand deposits, and is now part of the Bara Mana. The main thalweg (D1) has always been on the right side. Because of several transient bars not shown in the figures, the thalweg appears to be sinuous and is deep enough for ferry service between May and January. A less sinuous channel (D2) north of the Bara Mana is fordable throughout the year. In the dry season this channel almost disappears or becomes disconnected pools. As a result, Bara Mana becomes a part of the mainland (Plate 6.3a and Plate 6.3b) connected through this motorable channel. Despite enlargement since 1920, Bara Mana still suffers from bank erosion in many places (Plate 6.4). Contemporary hydro-geomorphological conditions on the left bank strongly indicate the merging of the Bara Mana with the mainland in the near future (Plates 6.1, 6.3a, and 6.3b).

Over the decades, grass-covered land of Bara Mana has been transformed into agricultural fields (Figs. 6.9, 6.10, 6.11 and 6.12). On the cadastral maps of 1957 some unauthorized agricultural fields are found and permanent settlements have arisen after 1957 and 1959 after completion of the Durgapur barrage, and the Maithon and Panchet reservoirs.

Bara Mana is dominated by Bangladeshi refugees. After 1978 a few locals migrated from the districts of Medinipur and Hooghly and have purchased land from refugees. The total population of Bara Mana is approximately 7,000.

6.3.5.1 Land Use Characteristics and Flood Zoning in the Riverbed

To examine changes on the bar and the land use characteristics, Bara Mana has been divided into six sections.
Section-1 comprising Bamandihi mouza are shown in Fig. 6.13 from which the following observations are made.

i. Grasses are allowed to grow on the erosion-prone bank
ii. Jute is cultivated in the next zone
iii. Double cropping is a common feature on the extreme west of Bamandihi
iv. Additional crops are grown in the unauthorized plots towards the north
v. Multiple cropping is practiced on higher land above the inundation level
vi. Linear settlements are to be found on higher ground in the flood-free area
vii. Linear settlements of low density are observed in inundation-prone areas towards the west. This part of the bar is also devoid of irrigation facilities.

Section-2 (Fig. 6.14) comprising Purakonda mouza shows more-or-less similar features. Some added findings are:

i. The river bed of the D2 and unauthorized land in the north are intensively cultivated (Plates 6.3b, 6.5)
ii. Cocoon rearing mulberry cultivation is observed on the highest part of the bar (Plate 6.6)

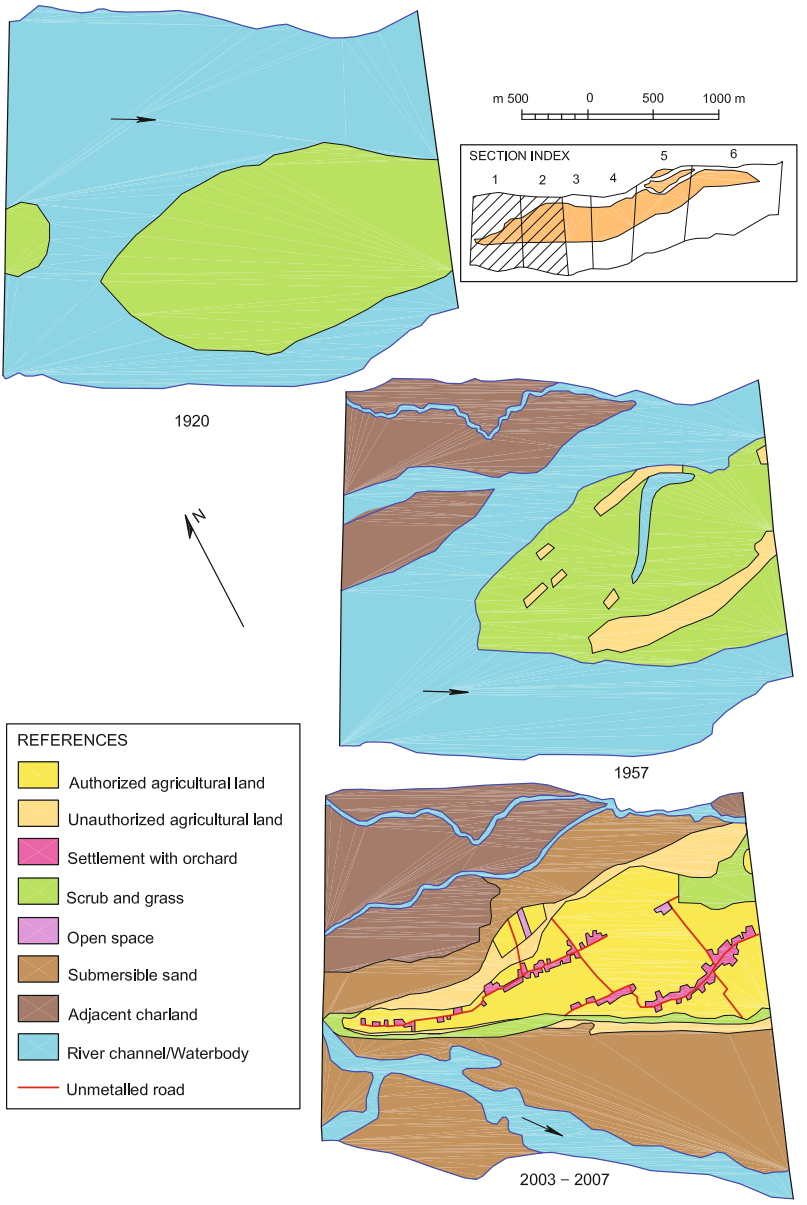

Fig. 6.9 Bara Mana (Sections-1 and 2): Changes in generalized land use characteristics and landscape – Bamandihi and Purakonda Mouza Maps
Map prepared through active field survey.

Bamandihi and Purakonda mouza, SOI 73M/7 (1:63,360, 1: 50,000 & 1: 25,000), and satellite image (2003) has been used to prepare this section of Bara Mana

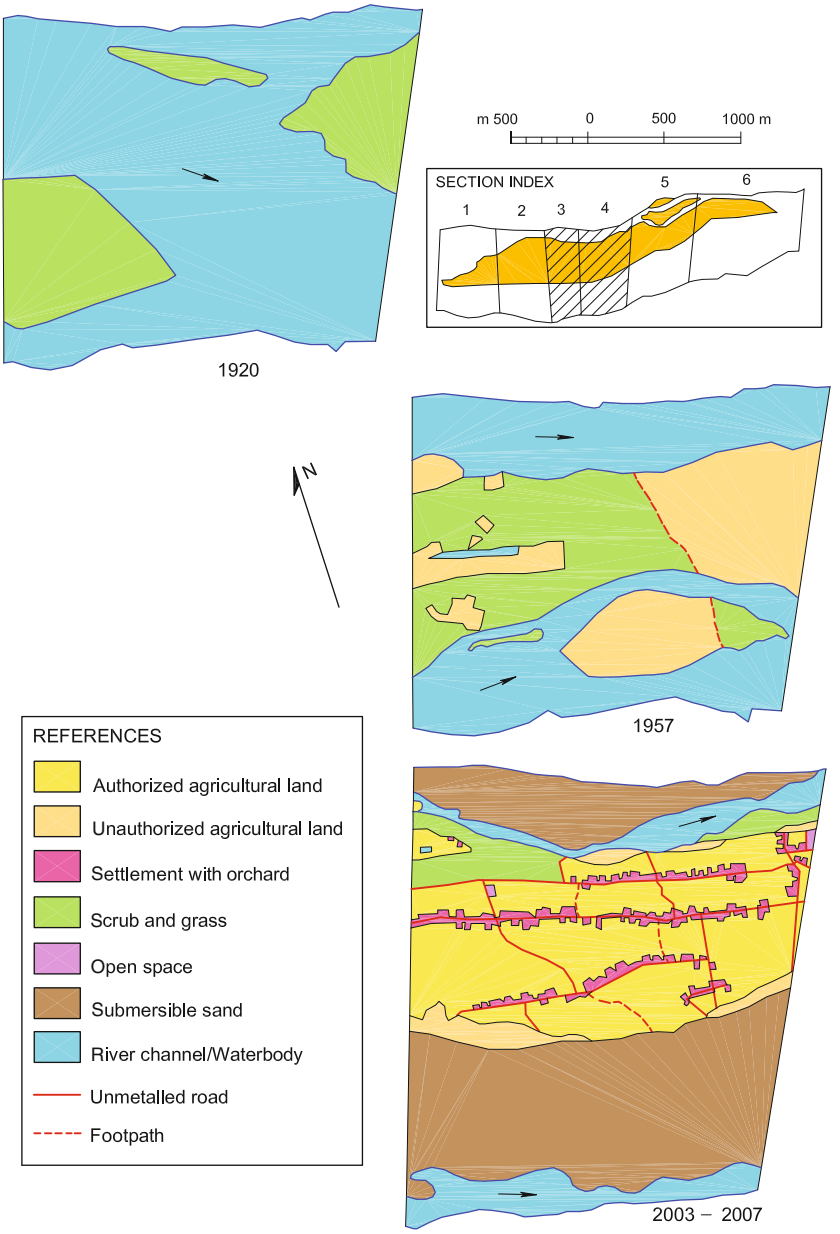

Fig. 6.10 Bara Mana (Sections-3 and 4): Changes in generalized land use characteristics and landscape – Tajpur and Pakhanna Bhairabpur Mouza Maps
Map prepared through active field survey.

Tajpur and Pakhanna Bhairabpur mouza maps, SOI 73M/7 (1:63,360, 1: 50,000 & 1: 25,000), and satellite image (2003) has been used to prepare this section of Bara Mana

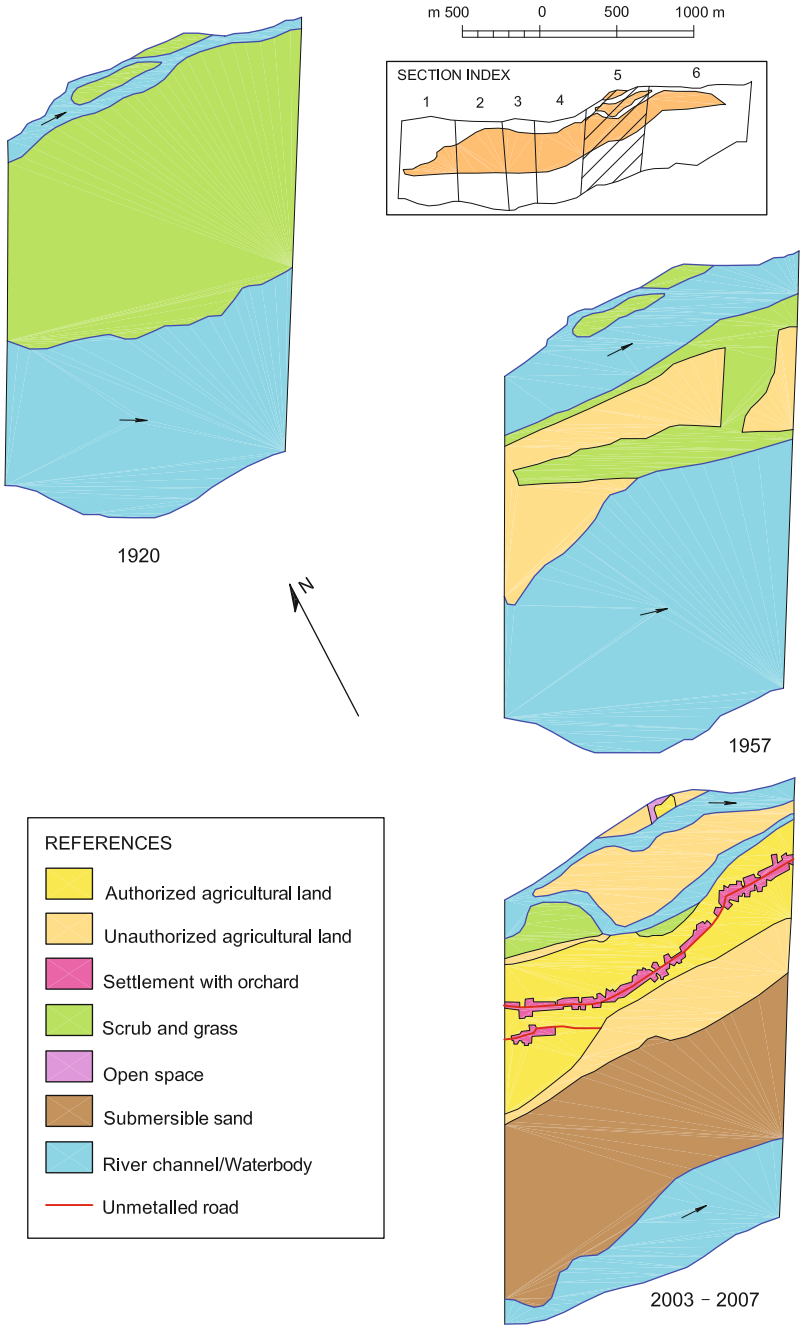

Fig. 6.11 Bara Mana (Section-5): Changes in generalized land use characteristics and landscape – Pakhanna Radhakantapur and Gopalpur Mouza Maps
Map prepared through active field survey.

Pakhanna, Radhakantapur, and Gopapur mouza maps, SOI 73M/7 (1:63,360, 1: 50,000 & 1:25,000), and satellite image (2003) has been used to prepare this section of Bara Mana

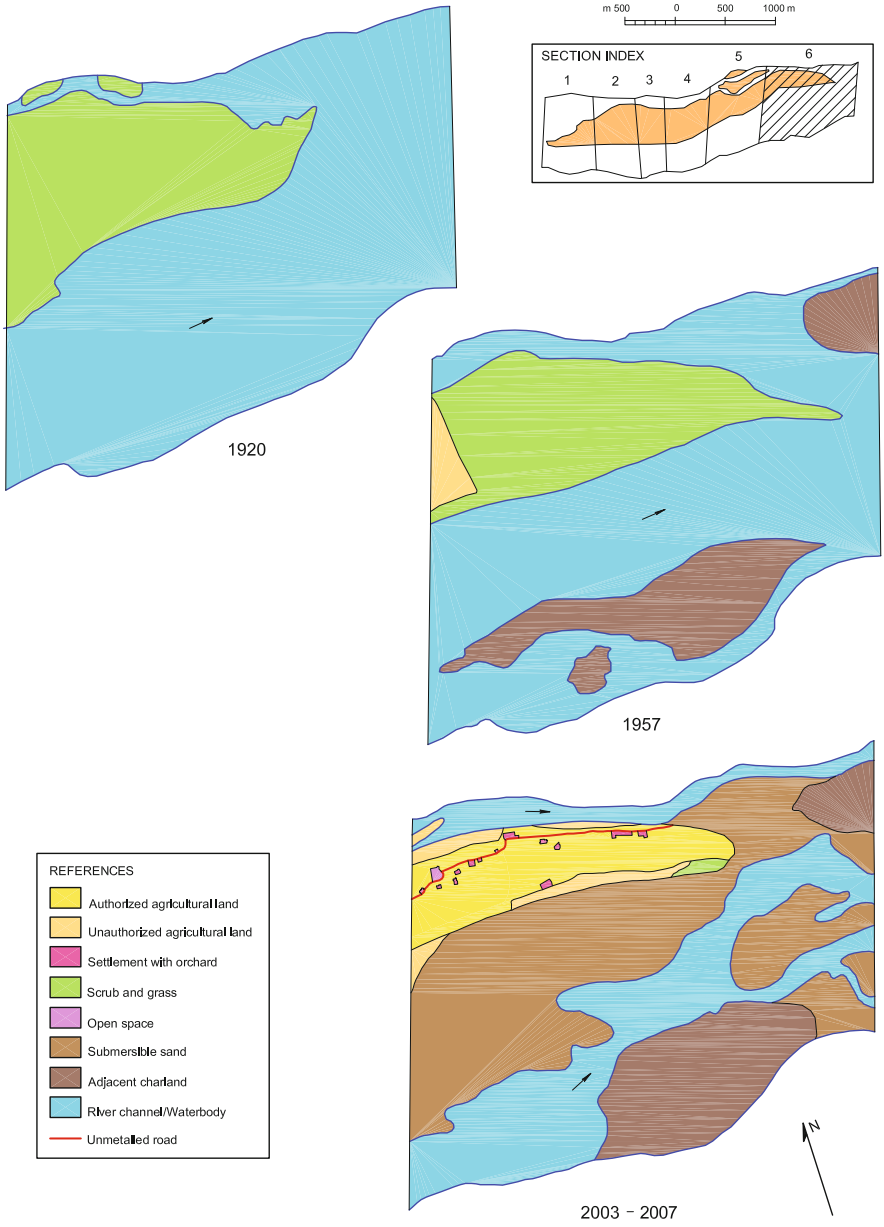

Fig. 6.12 Bara Mana (Section-6): Changes in generalized land use characteristics and landscape – Palasdanga, Joynagore, Alampur and Dihipara Mouza Maps
Map prepared through active field survey.
Palasdanga, Joynagore, Alampur, and Dihipur mouza maps, SOI 73M/7 (1: 50,000 & 1: 25,000), and satellite image (2003) has been used to prepare this section of Bara Mana

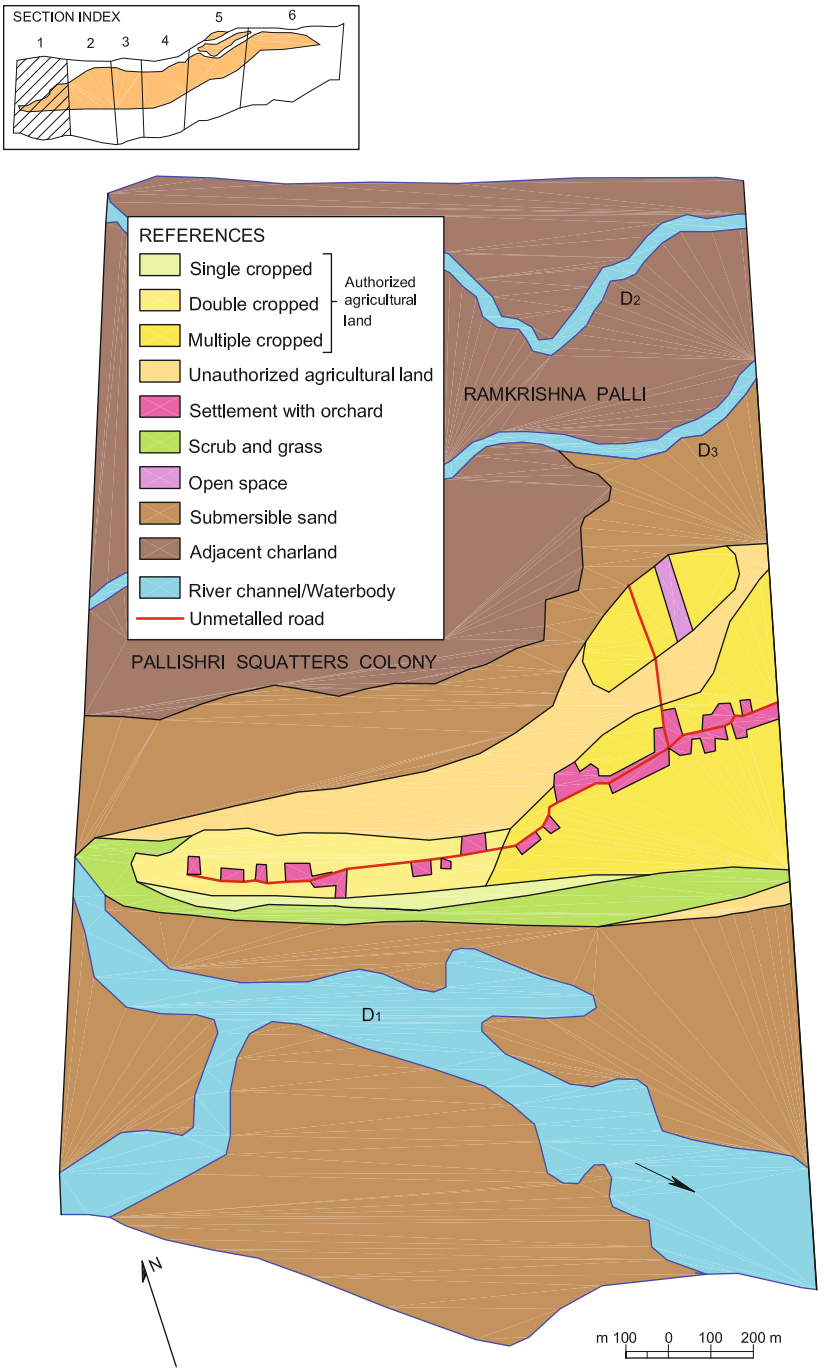

Fig. 6.13 Bara Mana (Section-1) land use characteristics: Bamandihi Mouza
Map prepared through active field survey.

Bamandihi mouza, SOI 73M/7 (1:63,360, 1: 50,000 & 1: 25,000), satellite image (2003) has also been consulted

iii. Clay deposits in the dried up channel D6 is used for rice culture
iv. Scrub and grass covered area is found to the northeast of this section.

Section-3 (Fig. 6.15) comprising Tajpur mouza shows:

i. Cocoon-rearing mulberry cultivation is found on the highest part of the bar
ii. Settlements are strikingly linear along the main road and located on higher ground (Plate 6.7a, 6.7b, 6.7c)
iii. Multiple crops are found on the higher parts of the bar with irrigation facilities (Plate 6.8a, 6.8b, 6.8c, 6.8d).

Section-4 (Figs. 6.10 and 6.16) comprising Pakhanna Bairabpur mouza shows:

i. Saha Mana, a small sand bar situated below, has completely merged with the Bara Mana due to continuous cultivation of the narrow channel between the two
ii. Linearity in settlement pattern is also observed
iii. Floriculture is found on the higher parts of the bar (Plate 6.9a, 6.9b)
iv. A cooperative society, club, play ground, and open space with school are found in this section. The open space with school is utilized as a shelter during high floods (Fig. 6.16).

Section-5 (Fig. 6.17) comprising Pakhanna Radhakantapur and Gopalpur mouzas shows:

i. The southern part is extremely erosion-prone as is observed from Fig. 6.17
ii. There are plots showing temples, ponds, school, and recreational ground
iii. The unauthorized agricultural fields in the northern and southern part are intensively cultivated for additional crops
iv. A small sandbar on the left bank has authorized agricultural fields but is devoid of any settlements.

Section-6 (Fig. 6.18) comprising Palashdanga, Joynagore, Alampur, Dihipara shows:

i. The Bihari-dominated part is not agriculturally developed
ii. The thalweg is striking in the extreme eastern part, so it is prone to erosion and inundation. This part shows single cropping
iii. The rest of the area exhibits double and multiple cropping
iv. The erosion-prone peripheral area is used as scrub or grassland or for additional crops.

Rice is the main cereal crop and jute has been the most important fibre crop from the very beginning of colonization. In later years, with the increasing stability of the bar, almost all types of vegetables, pulses, and different types of oil seeds are now grown. The most important cash crops, however, are mulberry and potato. Very recently floriculture has been introduced in accordance with the urban culture in nearby Durgapur town (Bhattacharyya 1998).

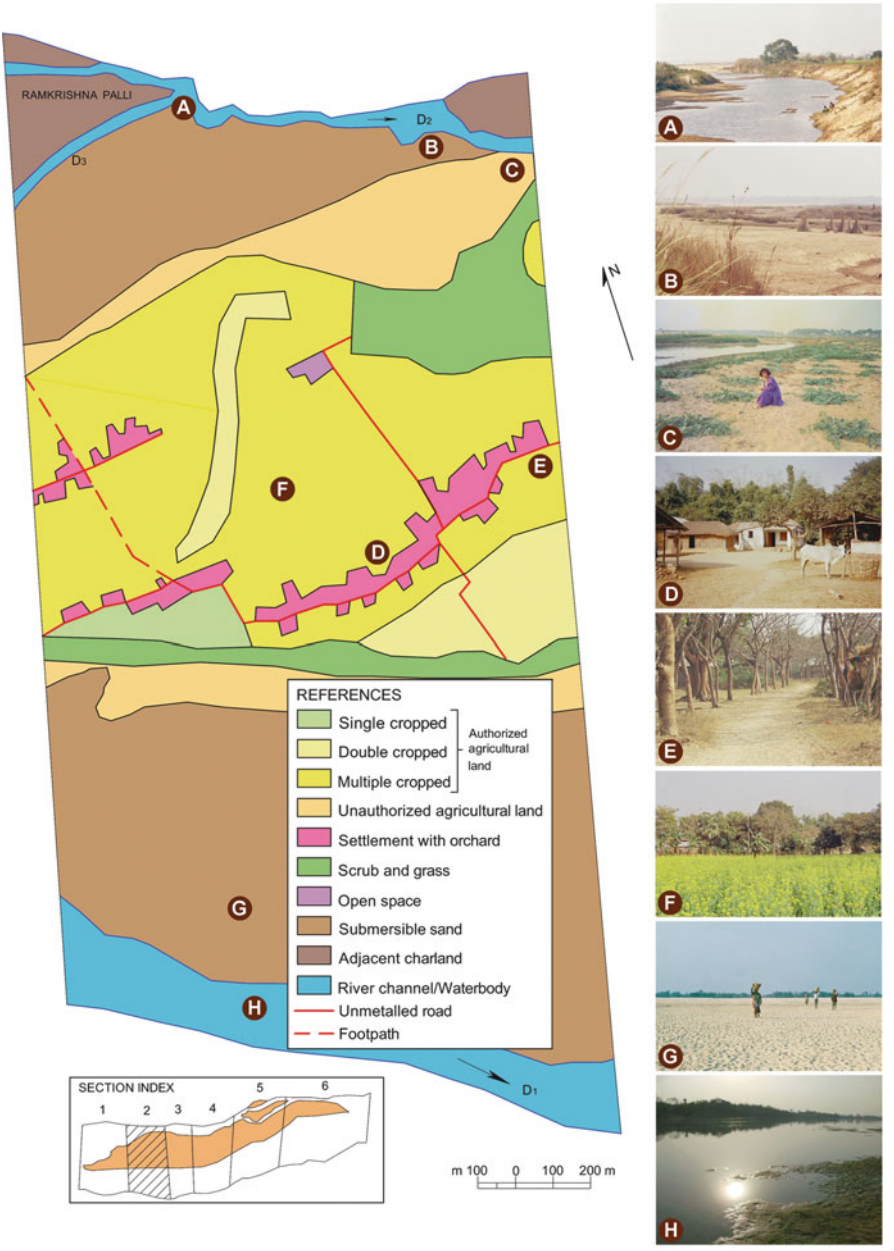

Fig. 6.14 Bara Mana (Section-2) land use characteristics: Purakonda Mouza
Map prepared through active field survey between 1994 and 1997 and 2007 and 2008. Purakonda mouza, SOI 73M/7 (1:63,360, 1: 50,000 & 1: 25,000), satellite image (2003) and land cover map prepared from satellite image of 1994 [IRS-IB LISS-2/FCC/classified image (1:100,000)] has also been consulted.

Bara Mana is an epitome of riverbed utilization. Every possible element of available land is put to some use so as to optimize benefits from micro relief variations, edaphic differences and water level fluctuations. Moreover, people's perception of the soil-binding capacity of roots is reflected in carefully maintained grassland in the erosion-prone area. In the decaying channel beds D_2 and D_3, clay deposited from vertical accretion is used for double cropping and the crop selected is clay-loving rice, the main cereal crop in Bara Mana. Jute, the most important fibre crop, is grown in the inundation-prone peripheral area and jute sticks provide building materials. Areas inundated almost every year are devoted to rice culture of High Yielding Variety (HYV) in the non-monsoon period. Residents can estimate how much area will be inundated if release of water below the barrage exceeds 2,832 or 5,664 m^3/s. The Sections, 3 and 4, including Tajpur and Pakhanna-Bhairabpur, are bounded with a 60 m contour with 62 m spot height which is shown on SOI map surveyed in 1970 (Fig. 6.19). These areas of Bara Mana were initially uneven in configuration but have now been leveled for agricultural purposes. An open space with school grounds located in it is believed to be the highest part of the sandbar and is used as a flood shelter during emergencies (Fig. 6.16). Bara Mana residents organize their agricultural space accordingly. Even if their lands get flooded and the usual agricultural calendar is disturbed, quick growing pulses, oil seeds, and vegetables are grown according to Nagen Tarafdar, a well known farmer of Bara Mana. A special type of onion that takes only 1 month to mature is grown in August and harvested in September. Radish is a preferred vegetable for flood-retreat land use. This type of cultivation is locally known as "Poira" cultivation. Fresh sands of low nutrient status in the peripheral zone are used for different types of gourds and melons (Plate 6.5). "Khero," one such variety of gourd previously not consumed by locals, is extensively grown now on fresh sands. These additional crops, requiring minimum care, now have ready markets in adjacent towns and villages. Riverbed depressions formed by scouring during floods are further excavated for household (Plate 6.10). Riverbed (D2) is also used for pisci culture (Fig. 6.16). The extreme flexibility of land utilization in Bara Mana is evidenced by the way in which flood-related loss of resource is compensated for through "Poira" cultivation, double and multiple cropping in certain areas, and also in the way crop diversity is maintained in order to avoid economic loss due to floods (Bhattacharyya 1998, 2009).

Fig. 6.14 (continued) **Plates**: A. Decaying drying channel (north of Bara Mana) 1997 photo courtesy of Durba Bhattacharyya; B. Jute cultivation on submersible sand at peripheral zone, Baramana 1997 photo courtesy of Durba Bhattacharyya; C. Additional crop cultivation on nutrient poor fresh sand at peripheral zone, Bara Mana 1996 photo courtesy of Durba Bhattacharyya; D. Settlement sited on the highest part of the sand bars Inundation susceptibility reflected in the structure of individual buildings 2000 photo courtesy of M Bharati; E. Linear settlements sited on higher parts of bars along the main road 2000 photo courtesy of M Bharati; F. Multiple cropping at Bara Mana 2008 photo courtesy of Bileswar; G. Lower Damodar below Durgapur Barrage during dry season Laborers going back to Bankura 2008 photo courtesy of Bileswar; H. Damodar thalweg on the right bank 2008 photo courtesy of Bileswar

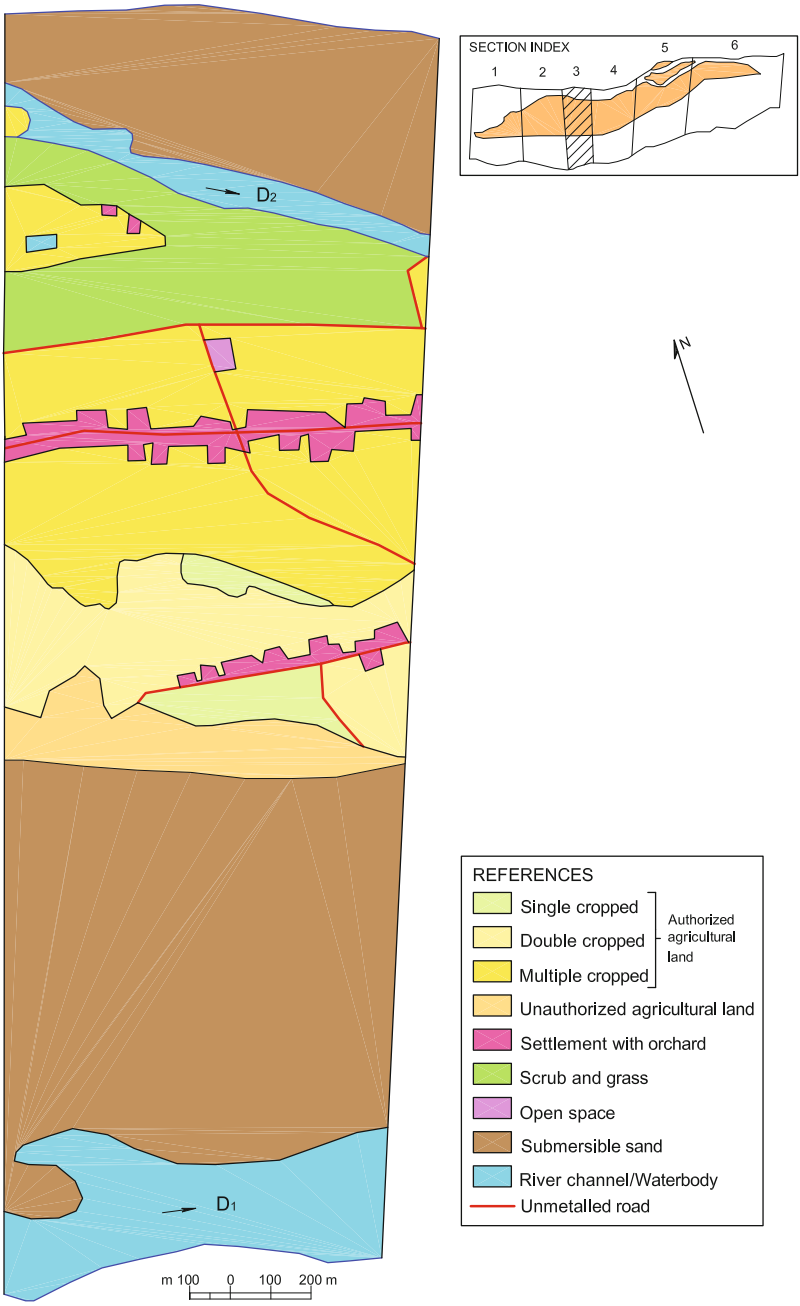

Fig. 6.15 Bara Mana (Section-3) land use characteristics: Tajpur Mouza
Map prepared through active field survey, Tajpur mouza, SOI 73M/7 (1:63,360, 1: 50,000 & 1: 25,000), satellite image (2003) and land cover map prepared from satellite image of 1994 [IRS-IB LISS-2/FCC/classified image (1:100,000)] has been consulted

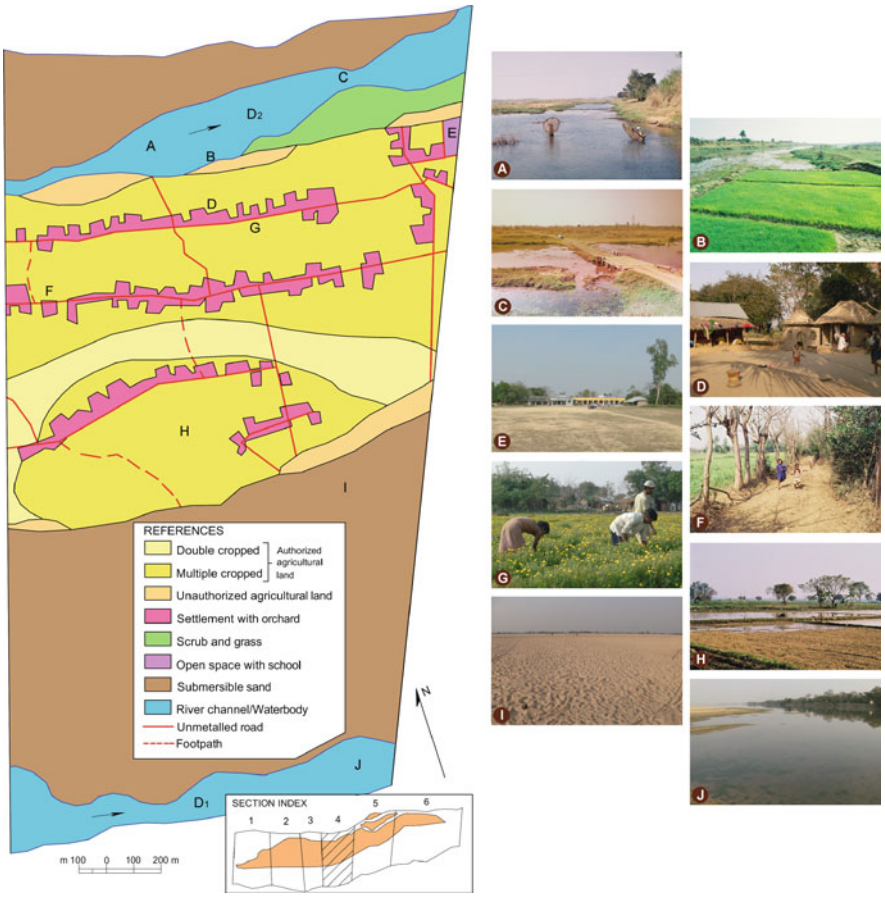

Fig. 6.16 Bara Mana (Section-4) land use characteristics: Pakhanna Bhairabpur Mouza
Map prepared through active field survey, Pakhanna Bhairabpur mouza, satellite image (2003), SOI 73M/7 (1:63,360, 1: 50,000 & 1: 25,000) and land cover map prepared from satellite image of 1994 [IRS-IB LISS-2/FCC/classified image (1:100,000)] has been consulted.
Plates: A. Pisci culture at D2 riverbed at Bara Mana (2000 photo courtesy of M Bharati); B. Additional crop at D2 channel-Bara Mana (2000 photo courtesy of M Bharati); C. Baramana becoming motorable during dry season (2000 photo courtesy of M Bharati); D. Settlement sited on the highest part of the sand bars Inundation susceptibility reflected in the structure of individual buildings (2008 photo courtesy of Bileswar); E. School at highest part of Bara Mana (2008 photo courtesy of Bileswar); F. Linear settlements sited on higher parts of bars along the main road (2000 photo courtesy of M Bharati); G. Floriculture at Bara Mana (2008 photo courtesy of Bileswar); H. Multiple cropping at Bara Mana (2008 photo courtesy of Bileswar); I. Lower Damodar below Durgapur Barrage during dry season (2008 photo courtesy of Bileswar); J. Damodar thalweg on the right bank (2008 photo courtesy of Bileswar)

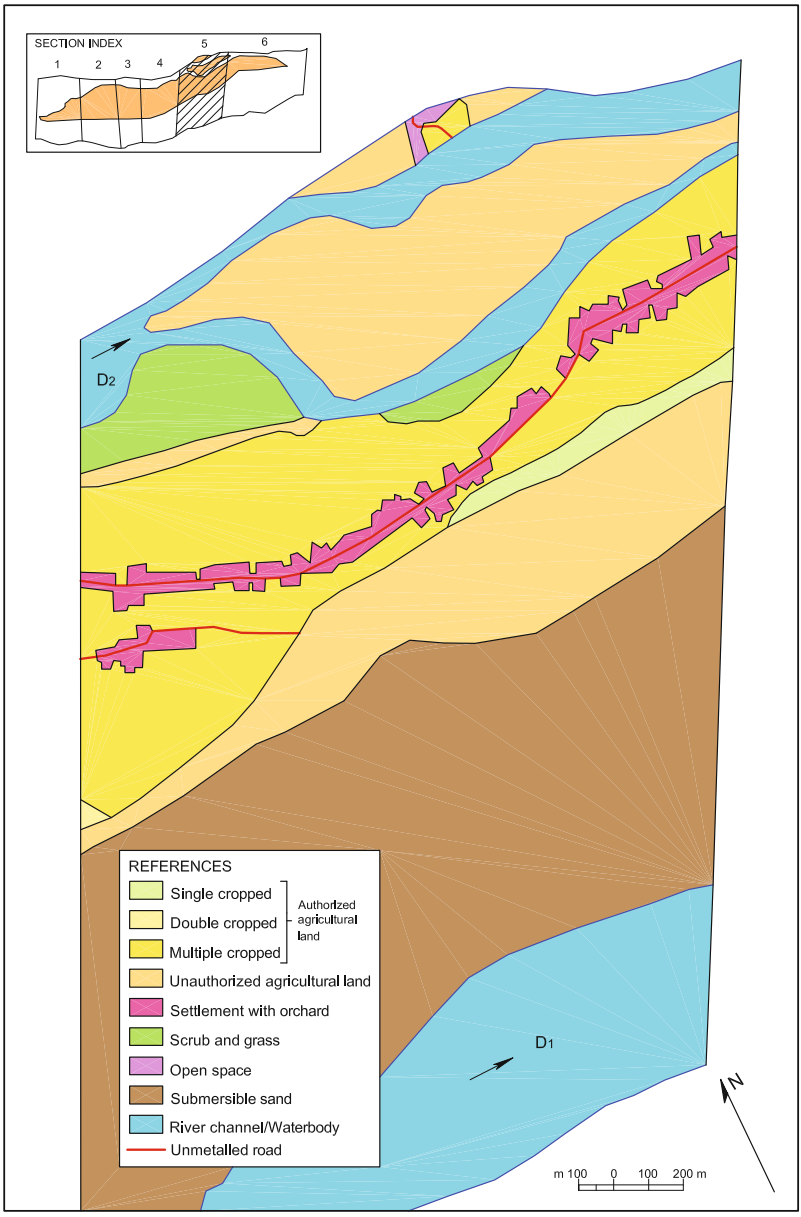

Fig. 6.17 Bara Mana (Section-5) land use characteristics: Pakhanna Radhakantapur and Gopalpur Mouza

Map prepared through active field survey, Pakhanna, Radhakantapur and Gopalpur Mouza maps, SOI 73M/7 (1:63,360, 1: 50,000 & 1: 25,000), satellite image (2003) has been consulted

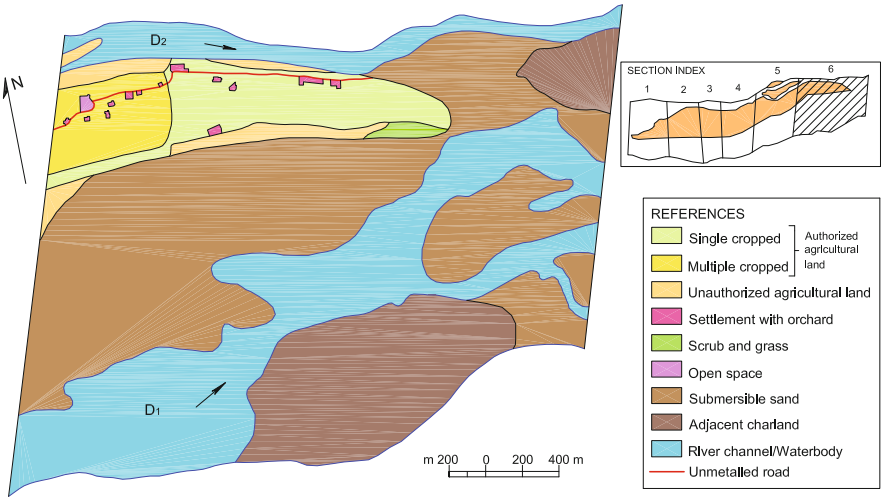

Fig. 6.18 Bara Mana (Section-6) land use characteristics: Palasdanga, Joynagore, Alampur and Dihipara Mouza
Map prepared through active field survey, Palasdanga, Joynagore, Alampur and Dihipara maps, SOI 73M/7 (1:63,360, 1: 50,000 & 1: 25,000), and satellite image (2003) has been consulted

Land utilization in Bara Mana shows an amalgamation of culture inherited from forefathers of the riverbed occupiers and culture acquired from other sections of the same community. The Bangladeshi refugees, used to rice and jute culture in their active deltaic habitat in Bangladesh, introduced these crops to their new habitat which happened to be in an active riverbed. The crops they have introduced at the commercial level are potato and mulberry. Potato cultivation, a part and parcel of Barddhaman and Hooghly culture, has been acquired from the locals. Potato cultivation requires constant vigil and on-site production cost is high. It is therefore grown in the vicinity of settlements and on inundation-free higher areas. Mulberry plantation together with cocoon rearing is also an acquired culture. Bankura and Bishnupur in the district of Bankura are noted for traditional silk. So are Maldah and Murshidabad in the district of Maldah and Murshidabad. These districts provide ready markets for the mulberry cultivated in Bara Mana. Like potato, mulberry, a perennial tree-crop, is expensive and is grown on the highest part of the bar which remains above water level throughout the year (Bhattacharyya 1998, 2009).

Awareness of inundation hazards is clearly evident in selection of settlement sites and use of building materials (Plate 6.7a, b, c). Although the main settlements are away from the thalweg, the bar remains exposed to floods if discharge from the barrage is above 5,664 m^3/s. During the 1978 and 2007 floods, with a peak flow of 9,345 and 7,808 m^3/s at Durgapur, the sandbar was submerged but the settlements were not totally washed away as the individual huts are on higher plinth and bamboo structures, deeply imbedded in the surface, can withstand flood currents. Individual rooms within the houses are equipped with high shelves for storage of valuables.

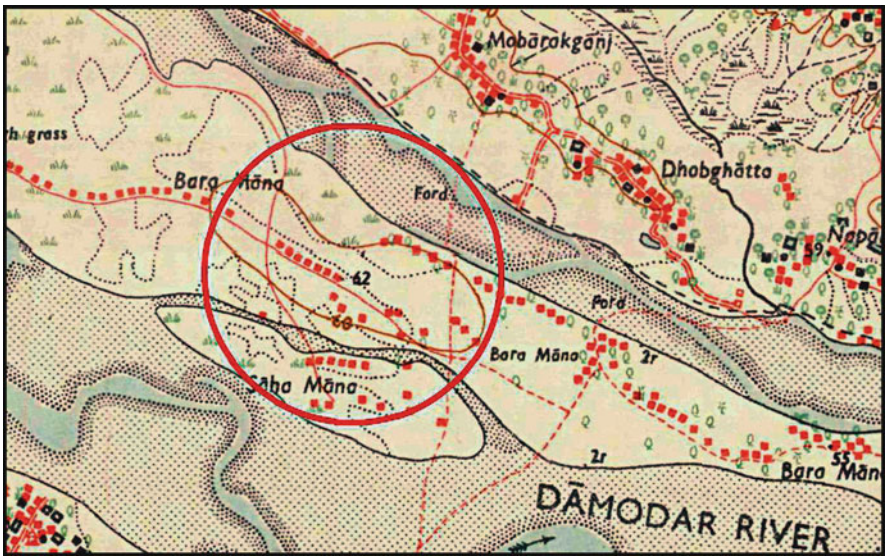

Fig. 6.19 Tajpur and Pakhanna-Bhairabpur in SOI map
Map prepared from SOI 73 M/7, scale, 1: 50,000.

This Sections 3 and 4, including Tajpur and Pakhanna-Bhairabpur (*circled in red*), are bounded with a 60 m (mean sea level) contour with 62 spot height as is shown on SOI map surveyed in 1970.

Communities take shelter here during high flood years. They perceive which parts of the bars will be inundated if water is released from the reservoirs and also whether their new niche would be inundated or totally destroyed during floods

The floods of 1978, 1995, 1999, 2000, and 2007 have improved the adaptive skills of the settlers. The planting of branching perennial tree crops such as mangoes and jackfruit after the 1978 flood serves a dual purpose. The fruits are consumed or sold at local markets and the trees provide shelter during floods in a region where, unlike the deltaic rivers, boating is hazardous (Basu 1988; Bhattacharyya 1998). In the floods of 1995 with a peak flow of 8,495 and 6,522 m^3/s, and in 2007 floods with a peak flow of 7,808 and 8,883 m^3/s from the Durgapur and Rhondia respectively, the bar was submerged in most places. People took shelter on these trees and on higher ground or on school ground, or temporarily deserted the inundated area (Bhattacharyya 1998, 2009).

Accessibility to market is important but more important is the use of market facilities. The emphasis on all types of vegetables, including highly perishable leafy vegetables, is due to market facilities at Durgapur and Panagarh, Pakhanna and Sonamukhi. Initially, the refugees used to be treated as parasites by the locals. But this parasitic relationship has been replaced by complementary and competitive relationships. Control structures have brought about several changes in the riverbed morphology and it is evident that the functional relations of the riverbed with its occupiers have changed more due to change in production relations. What was

once a self-supporting closed system is now a more open system with co-action and interaction with local people (Bhattacharyya 1998, 2009).

As far as the social space is concerned, the position of the refugees has not changed much on the horizontal scale, but on the vertical scale their economic status has improved and now they employ locals as laborers. Islanders have been granted ownership rights so they take immense care to stabilize the bar so that monitored release of water from the barrage cannot wash away their self-sought habitat. They have extended their resource base horizontally by using all available land, and vertically as well through multiple cropping (Bhattacharyya 1999–2000b, 2008b, 2009). In addition, they have been granted land deeds despite opposition from the DVC authority. Thus, what was once a group of mobile bars is now a static landform in a controlled riverbed within a graded time period. Finally, the land use characteristics have become viable parameters to assess microforms, processes and materials and inter-relationship between physical and selected components of cultural landscape. The diagrammatic Fig. 6.20 is a generalized model showing the inter-relationship between physical and selected components of cultural landscape.

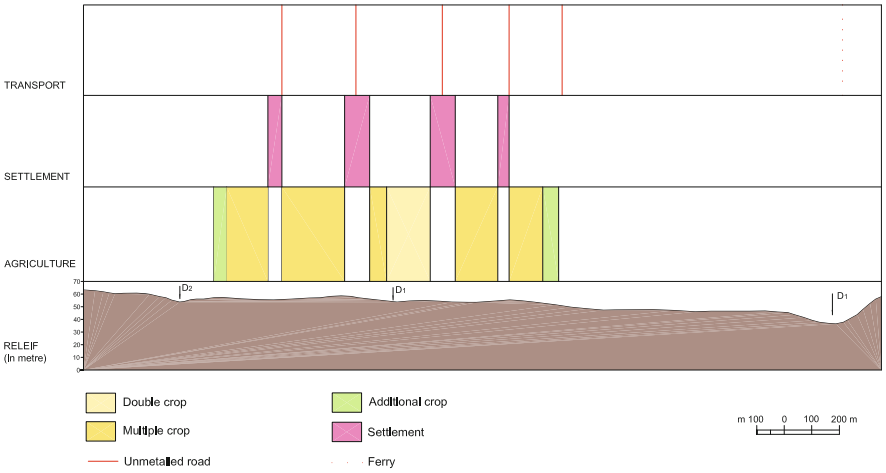

Fig. 6.20 Generalized model showing relationship between physical and cultural landscape

6.3.6 Rangamatia-Kenety Mana

Rangamatia-Kenety mana is under the Sonamukhi Police Station of Bankura district. It is under the mouzas of Rangamatia, Kenety, and some portion of the Nityanandapur mouza. In this particular bar, the width of the Lower Damodar is about 2.5 km in comparison to 0.7 km upstream of the Damodar bridge site and 0.5 km below the bifurcation point of the Mundeswari and Amta channel. There are three sandbars. One is the Uttar Rangamatia sandbar, the second is the Dakshin Rangamatia Kenety and some part of Nityanandapur (R.K.N) sandbar, and the third

is a small bar yet to be permanently settled. All these sandbars are situated in the dam area of the Rhondia weir (Fig. 6.21). The nearest town and railway station is Panagarh.

The changing boundaries of R.K.N. Mana are shown (Fig. 6.21). In 1920, there were only fragmented transient sandbars. By 1957, despite shape distortion and size reduction in some portions of the bar, land was added to the existing bars. Some new bars also appeared towards the left bank. The 1978 floods caused extensive damage to these bars and they were reduced in size as is evident (Fig. 6.21). The R.K.N. boundaries from 2003 LISS-3 scenes of the IRS-1D satellite show that the bars have grown in dimension but there are a few pockets of permanent bank erosion on the northern part of south Rangamatia sandbar. The thalweg has changed its position several times between 1921 and 2003 but retains its braided channel pattern. As in the other bars, surface materials vary from sand to clay.

People displaced from the former East Pakistan due to the partition of India in 1947 have settled in Rangamatia-Kenety and in Uttar-Rangamatia Mana. They occupied the area by force in the year 1955–1956 when they were deprived of their dole-sustained existence. Dakshin Rangamatia sandbar is settled mainly by refugees whereas the Uttar Rangamatia is dominated by local residents. A small sandbar just upstream of the Rhondia weir is now being occupied by refugee and local population as well. The number of households in Dakshin Rangamatia-Kenety-Nityanandapur

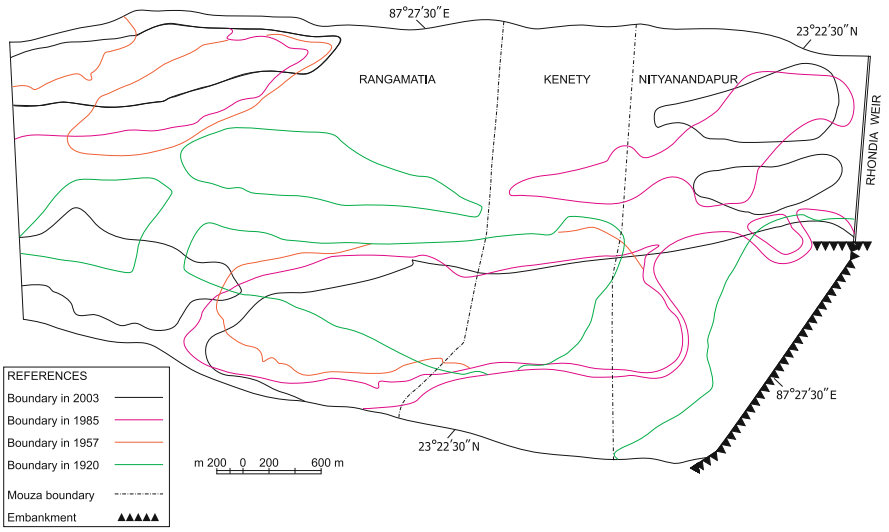

Fig. 6.21 Changing boundary of Rangamatia-Kenety Mana
Maps prepared from cadastral maps, SOI maps, and a 2003 LISS-3 scenes of IRS-ID satellite.

Cadastral Survey (CS) maps, surveyed between 1917 and 1924, and Revision Survey (RS) maps surveyed between 1954 and 1957 and several layout plans originally prepared between 1996 and 1997 and modified between 2007 and 2008, have been used. SOI maps of 73 M/7 N.E. 73 M/7S.E. (1:25,000), 73 M/7 (1:63,360, 1:50,000, 1: 25,000) have been consulted

sandbar is about 262. The total population is about 1,410. After the devastating flood year of 1978, people from Khanakul in the Mundeswari river of Hooghly district and from Ghatal of Medinipur district came to the Dakshin Rangamatia sandbar and purchased land from refugees. The number of households in Uttar Rangamatia is approximately 150.

Being situated within the Rhondia weir, the bars are vulnerable to frequent inundation but land use is finely adjusted with the fluctuating water level and is extremely flexible. Flood-prone peripheral areas, particularly in the north, are usually kept fallow. Extreme flood propensity at the margin does not allow for growing of additional crops but that is compensated for by intensive cultivation of rice in the inland areas. Almost all households have shallow tube-well facilities (Plate 6.11a). The sandbars were initially uneven in configuration but have now been leveled for agricultural purposes.

Rice is the main crop in the R.K.N. bar in both the Kharif and Rabi seasons. Jute has been a major cash crop right from the beginning. Almost all types of vegetables are grown in this bar because there is a ready market for them at Sonamukhi in Bankura and at Panagarh in Barddhaman district. Potato cultivation was introduced to the bar by local residents who migrated to it (Fig. 6.22).

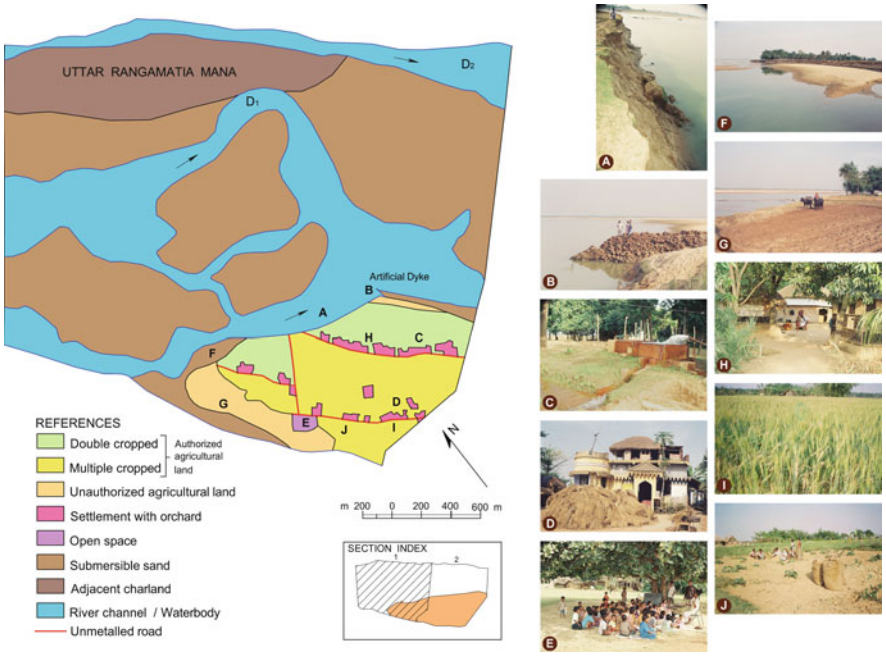

Fig. 6.22 Rangamatia-Kenety Mana (Section-1) land use characteristics: Rangamatia Mouza
Plates: A. Bank erosion at Rangamatia; B. Dyke to prevent bank erosion; C. Irrigation facilities; D. A newly constructed concrete house at Rangamatia Mana; E. Village school at Rangamatia; F. Submersible sand; G. Unauthorized agricultural land; H. Settlement with orchards sited on the highest part of the sand bars; I. Wheat cultivation; J. Potato cultivation

The settlements here are strikingly linear and are located at the highest elevations. They are being extended towards the Bankura side. The shifting of settlement sites from the inundation and bank erosion-prone area i.e. from north to south (Figs. 6.22 and 6.23) is noteworthy. Arquate shape of settlements (Fig. 6.23) in Nityanandapur indicates that they were developed alongside semicircular water channels that have

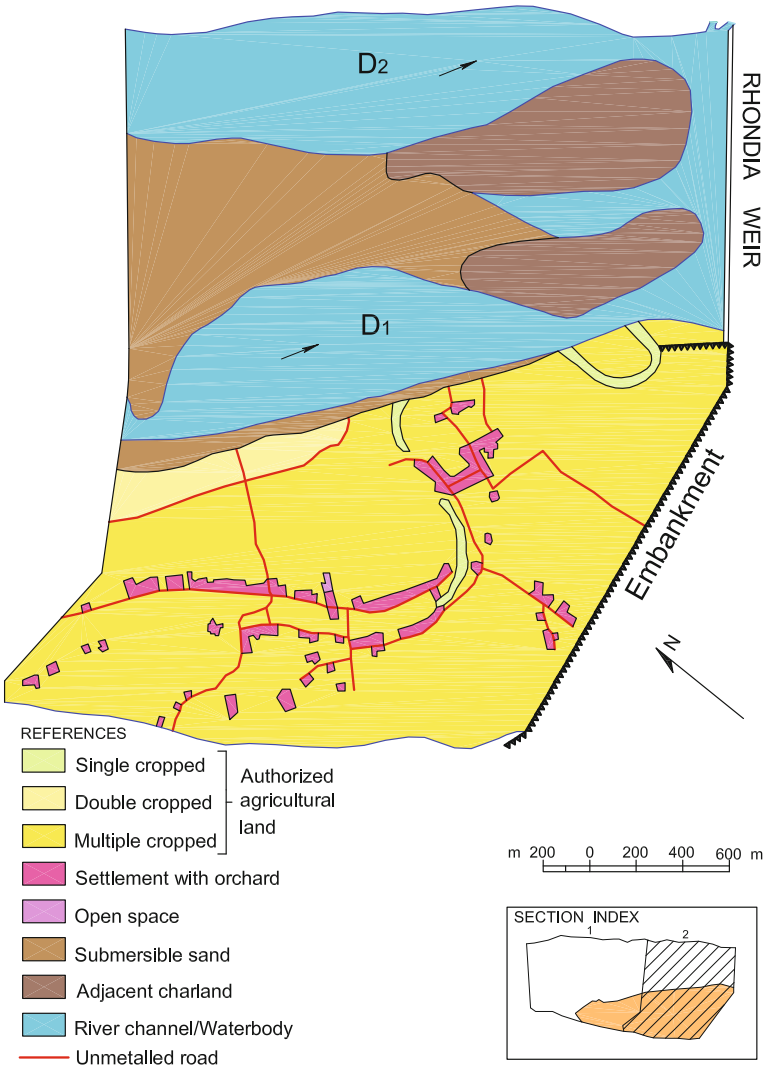

Fig. 6.23 Rangamatia-Kenety Mana (Section-2) land use characteristics: Kenety and Nityanandapur Mouza

Figures 6.22 and 6.23, prepared through active field survey and using several layout plans and cadastral maps (Rangamatia, Kenety, and Nityanandapur) Survey of India (SOI) maps of 73 M/7 N.W., 73 M/7S.E. (1:25,000), 73M/7 (1:63,360, 1:50,000) have been consulted.

nearly dried up. Some such channels can still be seen in the eastern side of the Nityanandapur Mana and are used for rice cultivation. Migrating locals have settled in isolated patches south of the main South Rangamatia Kenety settlements. They purchased land from the refugees and did not have much choice of a settlement site. Their settlement pattern, therefore, is rather amorphous (Fig. 6.23).

Because of high inundation risk, individual houses are constructed on higher plinths above the river water level. Inundation susceptibility is also reflected in the structure of individual buildings made of bamboo and jute sticks plastered with mud and other materials. If there is an unusual flood and the mud is washed away, people remove the bamboo structure to a safer location. In this way they reuse the original structures to construct new houses. Newly constructed concrete structures such as the village school and temple are also found in Rangamatia (Fig. 6.22, Plate 6.11b). The most striking component in the R.K.N. sandbars are the Rangamatia dams or dykes already mentioned.

"Aisab bandher jonno parer kshoy rodh kora jabe abon bandher opore uchhotay o prasthe otirikto jomi paoya jabe". Due to these dykes bank erosion will be arrested and there will be additional land due to vertical and lateral accretion above the dyke, said Binod Das, a well-known farmer, who took the initiative for planning and constructing a series of dykes in Rangamatia. Along the Missouri River in Montana, landowners believed that bank erosion is caused due to operation of the Fort Peck dam (Darby and Thorne 2000). Along the Damodar River, residents believed that operation of Durgapur barrage has initiated bank erosion (Bhattacharyya 1998, 1999).

6.3.7 Fatehpur and Kasba Mana

Just below the Rhondia weir, there is an elongated marginal bar dotted with the settlements of Beloa, Rupuisar, Fatehpur, Amritapara, Beshia, and Kasba (Fatehpur and Kasba Mana). These settlements come under the mouzas of Beloa, Rupuisar, Amritapara, Beshia, and Palsura of Sonamukhi police station under the Bankura district. The nearest town is Budbud and the nearest railway station is Panagarh.

While examining the evolution of the Ramkrishnapalli and Pallishri Colony sandbar, it was observed that the thalweg of the Lower Damodar has shifted from the left bank to the right bank. The same phenomenon is observed in the Kasba Mana. This Mana has nearly merged with the mainland with only a feeble channel, activated during floods, separating this sandbar from the mainland (Figs. 6.24, 6.25, 6.26 and 6.27). Between 1920 and 2003 the sandbar was transformed from isolated fragmented bars to an almost continuous sandbar. Enlargement of the bar is noticed towards the right bank. The evolution of the Fatehpur and Kasba bar from 1920 to 2003 is shown (Figs. 6.24 and 6.25). Notable characteristics include five transient sandbars situated within the braided Damodar in 1920 before the construction of the Rhondia weir. Then, the main thalweg was further north of the present thalweg. By 1957, before the construction of the Maithon (1957) and Panchet reservoir (1959) and the Durgapur barrage (1958) but after the construction of the Rhondia

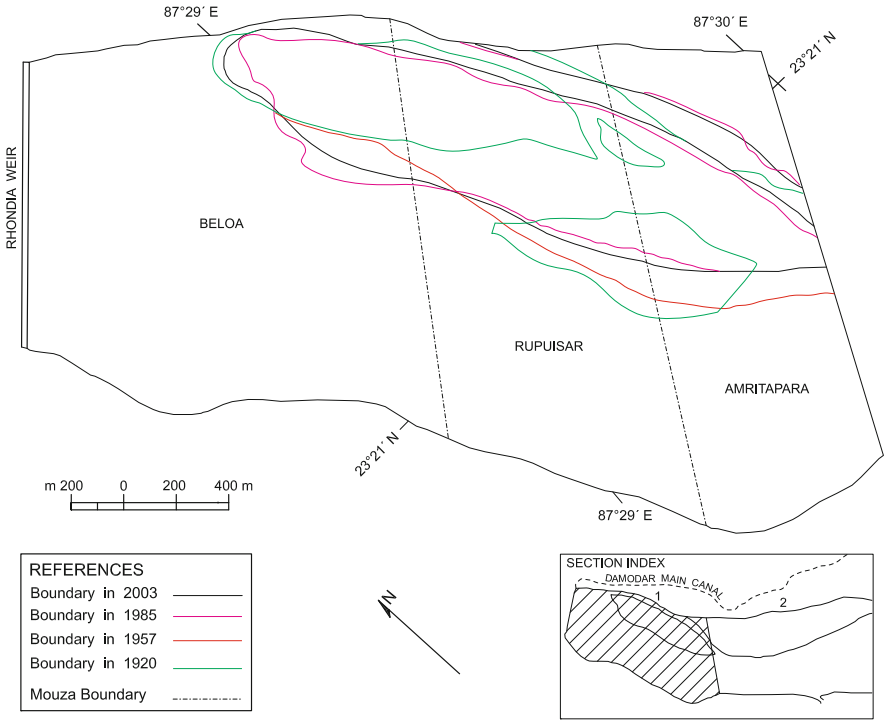

Fig. 6.24 Changing boundary of Fatehpur Mana and Kasba Mana (Section-1)

weir (1933), the two westernmost sandbars had merged together and two eastern sandbars had become continuous. Bank erosion is observed in some areas and the main thalweg has shifted to the right. By 1985 two big sandbars were observed. The channel separating this alluvial bar from the mainland appeared to be dead. Within the period of 1995–2003, the northern part of the Fatehpur and Kasba Mana sandbar had nearly merged with the mainland on the left. Within the bar there were a few channels that are remnants of the previous braided channel and the thalweg has shifted to the south. The right bank line has also shifted further south. This is evident from the 2003 LISS-3 scenes of the IRS-1D satellite.

Transformation of a mobile bar to a fixed bar is a common fluvial process in alluvial channels in their low gradient sectors. It is noteworthy, however, that significant changes have occurred to Fatehpur and Kasba Mana after 1957. It may be presumed, therefore, that detention of water behind the Rhondia weir since 1933 has reduced discharge below the Rhondia weir, creating a sluggish environment in the riverbed conducive to excess sedimentation. There may be a counter-argument that a weir is a local base level that was artificially created, and that river action is renewed below such a base level. It must be mentioned here that release of water from a control structure passes through a definite channel and this definite channel is usually the thalweg. Annual as well as monsoon discharge from the Rhondia weir

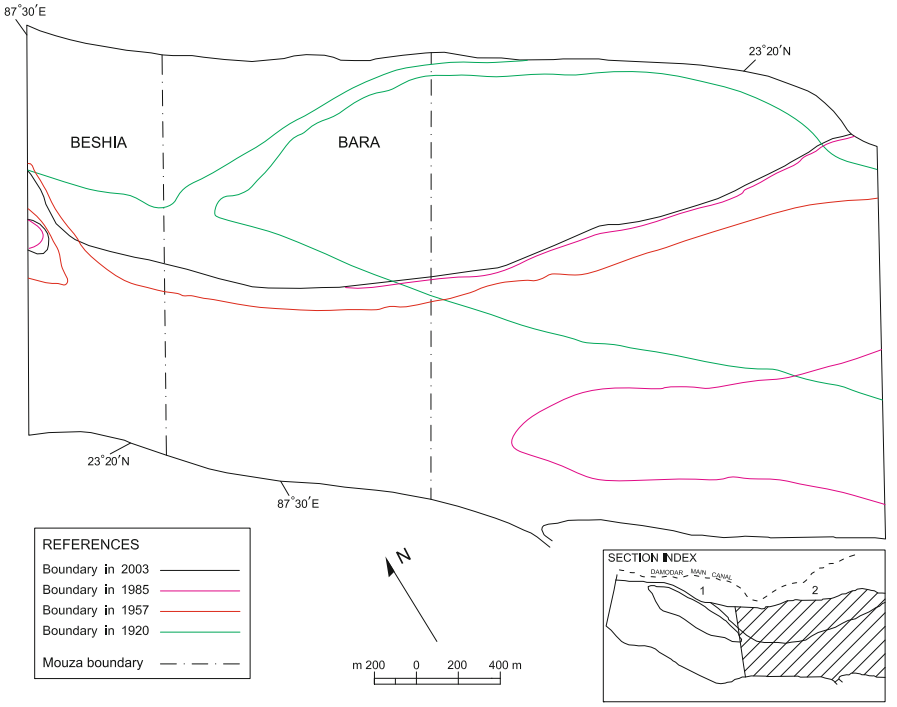

Fig. 6.25 Changing boundary of Fatehpur Mana and Kasba Mana (Section-2)
Maps prepared from cadastral maps (Beloa, Amritpara, Beshia, Bara Palsura, Rupuisar), SOI 73M/10, 73M/11 (1:63,360, 1:50,000), and 2003 LISS-3 scenes of IRS-ID satellite

has decreased (Table 4.3). Reduction in discharge can be attributed to the Damodar main canal which takes off from the Rhondia weir. Therefore, there has been more aggradation than erosion below the Rhondia weir. Construction of a weir in the River Kas, a tributary of the River Mula, Godavari basin, India has also affected the pattern and character of sediments. The Mula-Kas confluence sedimentology is a joint product of flow variability, confluence morphology as well as human activity (Unde and Dhakal 2009).

Between 1957 and 2003 the Fatehpur and Kasba Mana were reduced noticeably. As was noted before, the 1978 flood was considered the greatest disaster in south Bengal in the present century. The severe bank erosion and size reduction of this bar can be attributed to this flood (Figs. 6.26 and 6.27). A new bar, locally known as Chhita Mana, has emerged on the right bank. Bank erosion is still a problem on the right, i.e., on the southern part of the Fatehpur and Kasba Mana.

The Fatehpur and Kasba Mana settlements are dominated by Bangladeshi refugees. A few Biharis who migrated from Bangladesh can be found in the extreme eastern part of the Kasba Mana. The Fatehpur and Kasba Mana are extensively and intensively used by the Bangladeshi refugees. The erosion-prone peripheral area is used for additional crops such as cucumber and different types of melons. The main

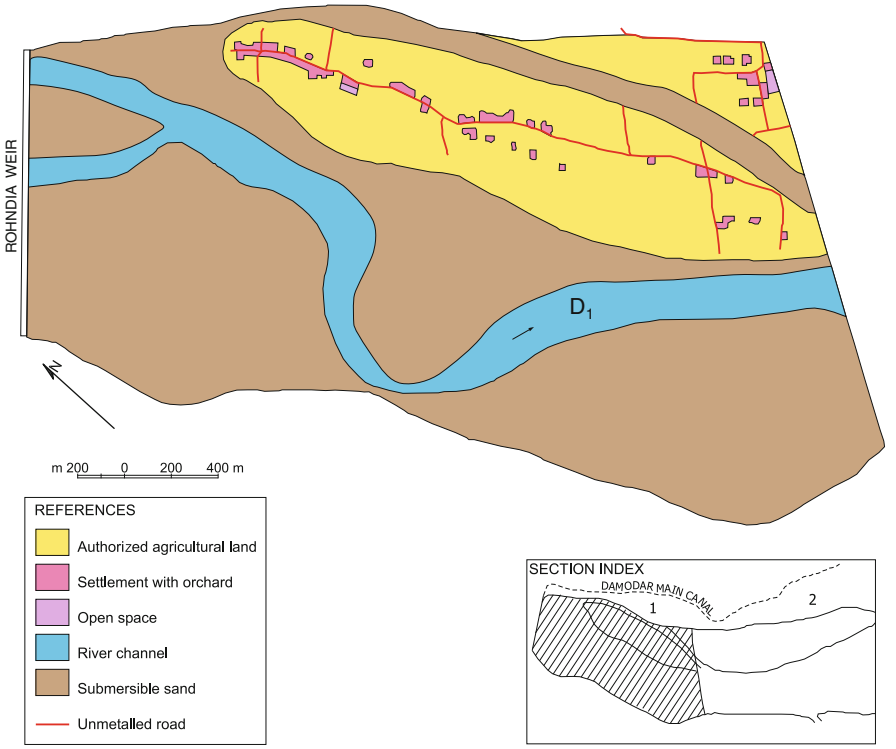

Fig. 6.26 Fatehpur Mana and Kasba Mana (Section-1): land use characteristics
Map prepared through active field survey with layout plans

crops are wet rice and jute. Since 1968, with the help of irrigation, HYV seeds such as *I.R.-8* and *Ratna* have been introduced to the bar. Irrigation facilities from shallow tube-wells have helped in generating wheat culture. Wheat is a more important crop in the Bihari-dominated sector of this bar. In examining the flood and colonization history of the Lower Damodar, we noted that the 1978 flood was followed by large-scale in-migration from Arambag and Khanakul of the Hooghly district to these sandbars. The Hooghly district is noted for potato cultivation, which was introduced to this sandbar by these local migrants. Potato is grown on the higher part of the sand bar. Among oil seeds, mustard is the most preferred crop in this bar.

Unlike Bara Mana, Ramkrishnapalli and Pallishri Colony, settlers on this bar do not grow other perishable vegetables on a commercial basis as the transport link between these bars and nearby urban centers is very poor. Potato is a non-perishable vegetable and, therefore, one of the most important cash crops along with jute. In recent decades, demand for jute has decreased all over West Bengal due to increasing use of synthetic bags instead of gunny bags. As a result, jute cultivation is being replaced by rice culture. Clay deposits accrued from slow vertical accretion in moribund channel beds are used for rice culture. An important

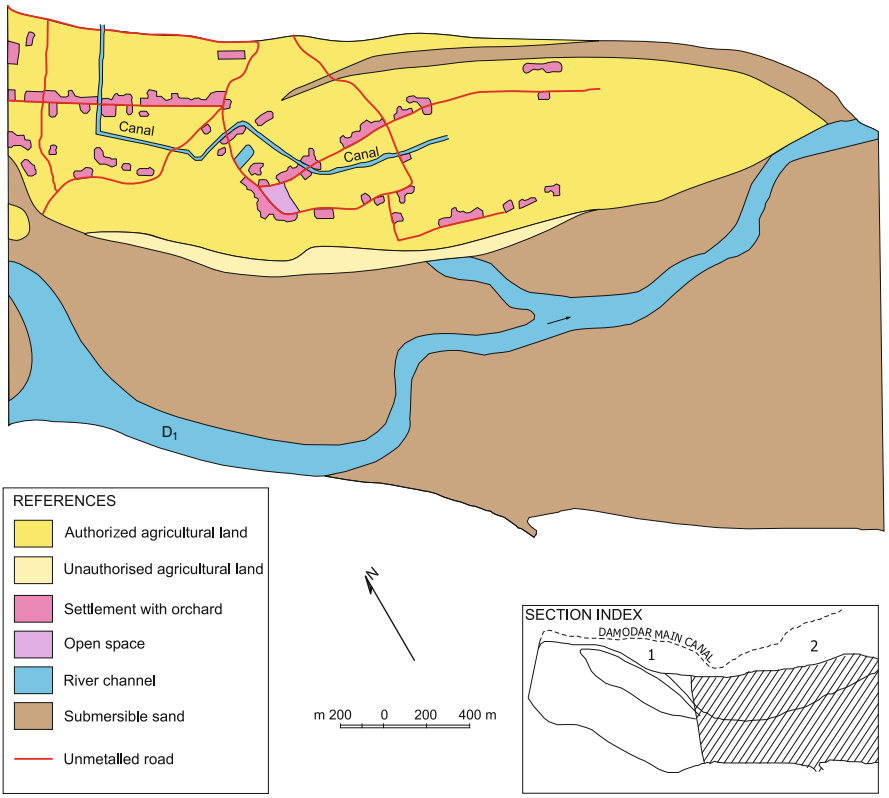

Fig. 6.27 Fatehpur Mana and Kasba Mana (Section-2): land use characteristics
Map prepared through active field survey with layout plans

and striking land use characteristic in the Kasba Mana is a subsidiary canal, which diverts water from the Damodar main canal but ends abruptly near the Bihari dominated part of the sandbar (Fig. 6.27). When the bar was first colonized, settlements were on the south, but the present settlements are to be found in the middle part of the bar. Settlement density is high in Beshia and in the western part of the Kasba Mana. Like other bar settlements, the Fatehpur and Kasba settlements are linear in orientation.

6.3.8 The Stretch Between Chhita Mana and Laksmipur Colony

The section between Chhita Mana and Laksmipur Colony falls under the Patrasayer police station of Bankura. The total length of this section is approximately 10 km. In this section lies the settled sandbar of Chhita Mana and a few other stable bars yet to be settled. On the left bank is Silla from where the left bank embankment can be observed (Fig. 6.28). There are double embankments, enclosing several hamlets,

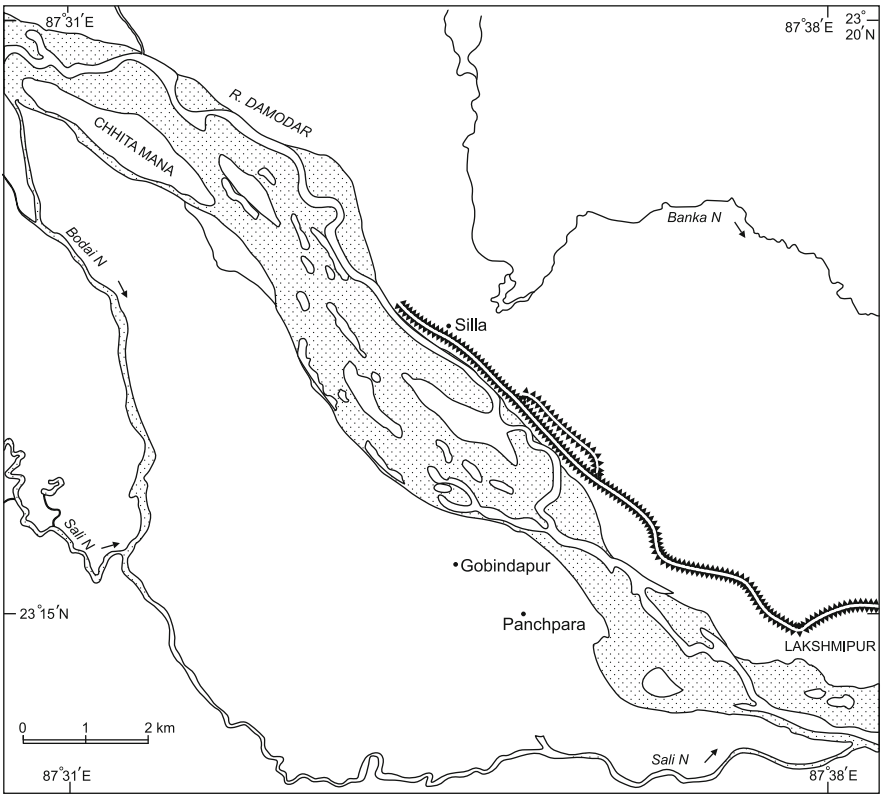

Fig. 6.28 The stretch between Chhita Mana and Lakshmipur Mana
Map prepared from 73 M/11 SOI map (1: 50,000)

between Kashpur and Bikrampur located below Silla. Gobindapur and Panchpara are the two important settlements in this section. They were once part of the riverbed but are now outside the channel boundary. The nearest railway station is Galsi which is quite far from this part of the lower Damodar. The Lower Damodar in this section has thrown several flood-channels on the right bank between Chhita Mana and Panchpara. The Bodai, one such flood channel, takes off at Bhaglui. There are several other linear lakes between Bodai and the main Damodar. These linear lakes may be the remnants of previous flood channels. If we join these linear lakes near Panchpara, we get the previous right bank of the Damodar between Dishinda and Panchpara.

In the SOI map of 1974, Panchpara and Gobindapur have been shown as two independent settlements. At the same time two other settlements named Gobindapur char and Panchpara char have also been shown. Since char refers to sandbar in Bengali, it may be presumed that these two char settlements were sited at the riverbed but now have merged with the mainland (Fig. 6.28). Merging of sandbars with the mainland is also observed in the case of Ramkrishnapalli and Kasba Mana. Between Bhaglui and Gobindapur char, the thalweg has shifted to the north and the

riverbed is almost choked with transient bars. Ferry service is restricted between June and November. Otherwise the river, except for the thalweg, is almost fordable throughout the year. Near Panchpara the Damodar is less than 1 km wide, its narrowest width between the Panchet reservoir and Barasul-Chanchai. This is due to merging of previous sand bars with the mainland.

The sandbars between Chhita Mana and Laksmipur Colony are dominated by Bangladeshi refugees who migrated from the government sponsored Bishupur camp. The main Gobindapur and Panchpara settlements, in contrast, are settled only by locals. The main crops are rice and potato. The HYV variety of rice includes *I.R.-36*. As the settlements are far away from major urban centres, vegetables are not grown on a commercial basis. In this respect they can be compared with the Fatehpur and Kasba Mana. The Gobindapur–Panchpara char settlement, like the other sandbar settlements, is strikingly linear as well.

6.3.9 Majher Mana

Majher Mana is a mid-channel bar located below the Rhondia weir under the police stations of Indus and Galsi of the districts of Bankura and Barddhaman, comprising portions of the cadastral maps of Somsar (Indus P.S.), Bhasapur and Sikarpur (Galsi P.S.). The nearest railway station and town are Khana and Gohagram respectively.

In Dickens's map of 1854 a mid-channel bar covered with grass jungles has been shown and is referred to as Baseepoor, which means inundation-prone. By 1929–1930 (SOI map) Baseepoor had merged with the mainland, but a group of small islands had emerged just below it. By 1954 these fragmented bars had been united to form the present Majher Mana (shown in cadastral map 1954, SOI map, 1969–1970). Some significant changes have occurred since 1854 (Fig. 4.14). During the 1978 floods, the eastern part of the Majher Mana was totally destroyed, but enormous amounts of sand were deposited on the western end. The eastern end is still erosion-prone and Majher Mana is still growing to the west (Fig. 6.29). It is separated from the Lakshmipur Mana (previous Baseepoor) by an incipient channel which is fordable in dry months. Lakshmipur Mana is under continuous threat from this incipient channel which becomes torrential during flood years. Sand quarrying from boats is a spectacular activity in Majher Mana (Plate 6.12).

Like other alluvial bars in the Lower Damodar, Majher Mana is settled by Bangladeshi refugees. Like Bara Mana, Majher Mana is an example of the optimum use of every inch of available space, the extent of which varies from year to year depending on the degree of floodability of the char land and irrigation facilities. Land use is thus very flexible. Wild grasses or additional crops of low value are grown on the inundation-prone peripheral zone, while paddy, oilseeds, potatoes and vegetables of high value are grown on higher elevations. Perennial mulberry plantations are to be found together with settlements on the highest part of the bar. The concept of flood zoning is applied here with the spatial extension of each zone, particularly on the bar margin, varying from year to year. Mulberry plantations, however, do not experience flooding as these are sited above inundation level (Bhattacharyya 1998).

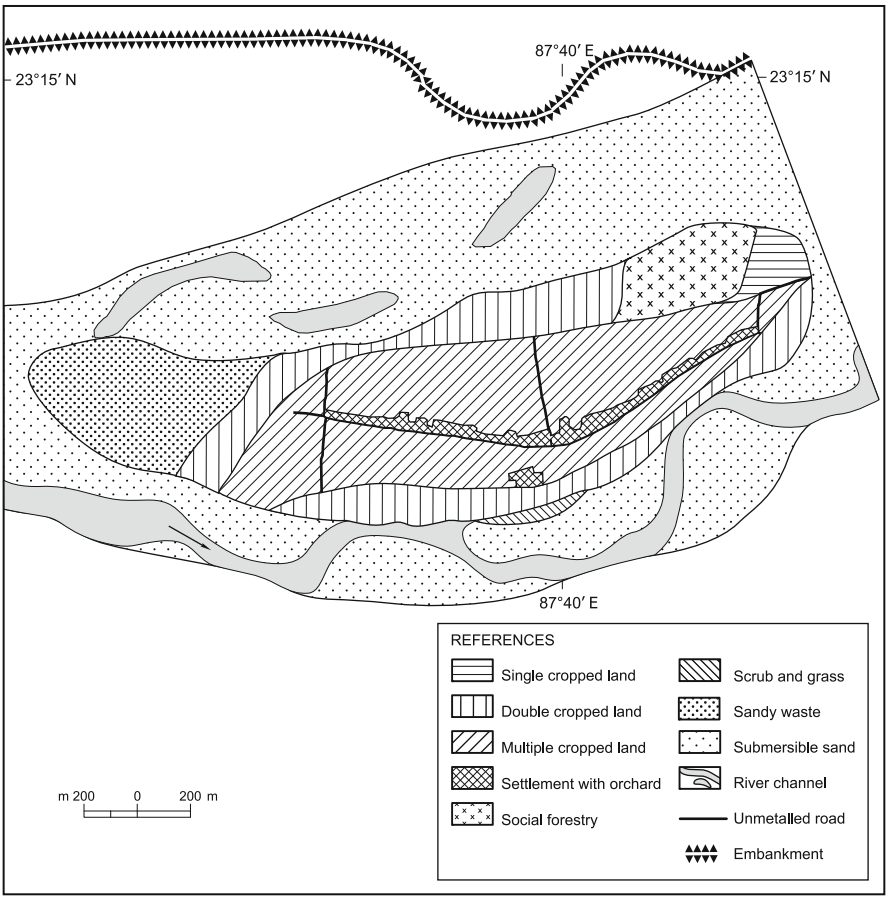

Fig. 6.29 Majher Mana Land use characteristics: Somsar, Bhasapur and Shikarpur Mouza Maps Map prepared from field survey, cadastral maps of Somsar, Bhasapur, Sikharpur of Galsi Police station, SOI (73 M/15/16, 1: 63,360, 1: 50,000), a 2003 LISS-3 scenes of IRS-ID satellite, and from a map of Dickens (1984) are shown

In Majher Mana flood deposits of 1978 and 2007 are being reclaimed for rice, jute culture and additional crops, particularly in the western part. As in the other sandbars, the settlement pattern is linear and individual houses have been constructed on higher plinths. Dried up channel beds are used as roads during the non-monsoon period.

6.3.10 Satyanandapur–Kalimohanpur Sandbar

The Satyanandapur–Kalimohanpur sandbar is sited just below the Jujuti sluice. The nearest railway station is Barddhaman. Bus service has only existed since October 1997. The Baka Nala, a former distributary of the Lower Damodar, flows close to

this bar towards the north. This distributary was highly unstable in this area as is evident from the SOI map of 1969–1970. The Banka was highly sinuous and there are several decaying, drying meander scars and flood channels still to be observed. The behavior of the Banka necessitated construction of double embankments with heights of 35 and 26 m. Nowhere in the study area are the embankments so high in altitude. The second embankment is motorable and there is a culvert for passage of Banka water into the river. Dickens's map of 1854 and the SOI map of 1929–1930 show this elongated bar as barren land with a flood channel to the north. At present the thalweg is on the right (Fig. 6.30) though the depth is not very significant and ferry service is only available from November to March.

The Damodar has created several flood channels between the Damodar-Sali confluence and Khalpara. Decaying drying flood channels are still to be seen as disjointed linear lakes. The northern branch of the Damodar just below the embankments is being activated and bank erosion is a major problem for the settlers. The floods of 1978 did considerable damage to the bar as the embankments were breached at several points. Bar materials vary from sandy loam to clay. The Satyanandapur–Kalimohanpur bar is settled by Bengali and non-Bangladeshi refugees and local residents. The non-Bengalis are from Uttar Pradesh. They went to the former East Pakistan from Uttar Pradesh to work as boatmen. After the partition of India they migrated to India together with Bangladeshi refugees. This bar was severely damaged during the 1978 floods with large-scale evacuation of people from the bar to the mainland. The abandoned lands were sold to local Bagdis, a scheduled caste community who keep the lands as fallow as they do not have the means to cultivate them. The main crop here is wet rice. Potatoes and other vegetables have recently been introduced as well after the extension of bus services from Udaypalli to Belkash. Now the emphasis is on high yielding varieties of rice and potatoes. Previously the settlements of Satyanandapur and Kalimohanpur were separated from each other with Satyanandapur close to the embankment and Kalimohanpur nearer to the thalweg. Both the settlements had a linear orientation. This linearity was disturbed by the 1978 floods. A new line of settlements has developed very close to the embankment and a new colony is developing between the double embankments on the left bank. Changing riverbed morphology from Jujuti to Gaitanpur has been shown (Fig. 6.30).

6.3.11 Gaitanpur

Gaitanpur in Gaitanpur mouza under the police station of Khandaghosh is located south of Barddhaman town. The nearest railway station and town is Barddhaman. Dickens's map of 1854 shows Gaitanpur as a marginal bar. In the SOI map of 1930 it appears to be a point bar with the Damodar thalweg towards north but the SOI map of 1970 and 2003 LISS-3 scenes of the IRS-1D satellite show Gaitanpur as a mid-channel bar, but the bar is merging with the mainland as is evident during 2008 field survey. The noticeable change that has occurred is the shifting of the thalweg from north to south. The previous thalweg is used as a flood channel. In the

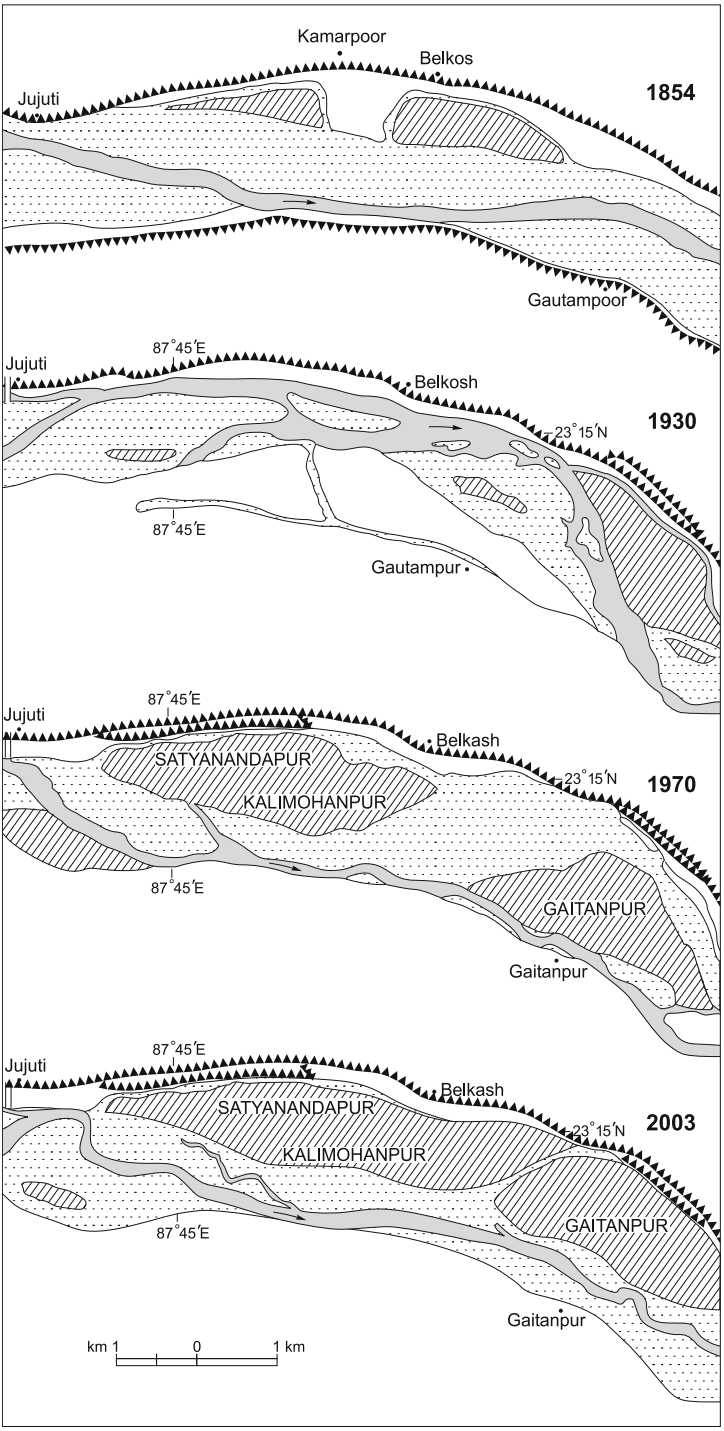

Fig. 6.30 Changing river bed morphology: Jujuti Sluice to Gaitanpur

non-monsoon period, the bed of the flood channel looks like a beaded string with riffles and pools. Another observable feature is the double embankments towards Barddhaman that are indicating the erosive capacity of the old thalweg during floods (Fig. 6.30). The total population in the sandbar is approximately 260 with Biharis dominating. Surnames such as Chowdhury and Nishad indicate that they were fishermen by profession. Therefore, when they migrated from Bihar around 1952 in search of jobs, they preferred a riverine location. Though the number of Biharis has decreased, they are still the majority group in this sandbar. Recent residents include the Bangladeshi refugees who settled here after the Bangladesh war of 1970. It may be presumed that Biharis were initially employed as village watchmen and gatekeepers by the Burdwan Raj and that they were given landed property during the period of the Burdwan Raj.

The floods of 1978 not only remarkably reduced the Gaitanpur bar in size, flood-borne sands nearly covered the landscape and made an extensive area unfit for cultivation. The floods of 1995 and 2007 have again activated the flood channel and extensive protective measures have been taken. Fresh sands that were used to support guava orchards have now been consumed by recent floods. Cattle rearing is a preferred occupation among Biharis. So grasses on fresh sands are used as grazing grounds and almost all houses have cattle sheds (Plate 6.13).

Since Barddhaman is noted for three types of sweets, Sitabhog, Mihidana and Langcha, there is a market for cow and buffalo milk. There is also a market for beef. Barddhaman was under Muslim rule from 1200 to 1650 A.D. (Choudhury 1991) and there is a sizeable number of Muslims in the town and in adjacent areas (850,951 approximately). Hindu Biharis do not consume meat and Muslims use the market facility to sell beef in the town. Apart from cattle rearing, Biharis grow wheat whereas Bengalis opt for paddy culture. As the bar is vulnerable to flood havoc, quick-growing paddy species like *1000, 10; 1000. 11; 1000, 12; Pankaj and Lalsarna* are selected. These species can withstand inundation for 4–5 days. With the lowering of river level just after the monsoon, the first crops grown are mustard. The exposed bed of the decaying flood channel is also used for quick-growing vegetables and oil seeds.

Heaps of fresh sand are still to be found in Gaitanpur. Sometimes these sands are put to agricultural use by applying an indigenous technique. A series of holes are made with an iron cone to reach the clay layer beneath. The holes are then filled with fertilizer and covered. The seedbed is then prepared. Using this technique

Fig. 6.30 (continued) The maps drawn from the Survey of India (SOI) maps of two series (73 M/15/16, 1: 63,360, 1: 50,000), 2003 LISS-3 scenes of IRS-ID satellite, and from a map prepared in 1854 by Captain Dickens. Calcutta, at a scale 1: 126,720 are shown.

This shows changes in the river between 1854 and 2003. In 1854 the river occupied a portion of the area divided by semi-transient unvegetated bars. By 1930 several migratory char lands are seen covered with grass and xerophytic bushes. By 1970, the main flow is on right side and diminished, the stream flow has been divided by stabilized char lands covered with agricultural fields and settlements. People have occupied these sand bars. In 2003, the sand bars are getting enlarged and merging together

roots can draw required nutrients from impermeable clay layers. This technique is applied by the Biharis only. In recent years potato has been introduced to the bar together with floriculture. Marigold is grown using the dew irrigation technique. An occasional cold wave in winter, though hazardous to potato cultivation, is suitable for flower culture. Settlement-wise there are two distinct colonies, the Bihari colony and the Bengali colony. The same linear pattern seen in other bars is repeated in this bar.

The above discussion makes clear how the same resource base is perceived differently by different cultures and how resource scarcity initiates reutilization of a defunct resource. In Gaitanpur bar, floriculture has been introduced to supply the urban area in nearby Barddhaman town (Bhattacharyya 1998).

6.3.12 Fakirpur Sandbar

Fakirpur is a tadpole-shaped marginal bar south of Barddhaman (Fig. 5.2). This is the last important settled bar above the Barsul-Chanchai flexure. Below Fakirpur the Damodar narrows down and there are several transient bars. Fakirpur is well connected with Barddhaman town. Fakirpur is separated from Gaitanpur by a flood-channel and this flood-channel is still observable up to Sadar ghat. The channel is activated in every rainy season. Fakirpur is protected by an embankment towards Barddhaman. The main thalweg is on the right bank. The Eden canal runs almost parallel to the embankment towards southeast of this bar. Lateral movement of the flood channel has now been protected by boulder pitching and a second embankment has been raised.

The Fakirpur sandbar was severely damaged in the 1978, 1995 and 2007 floods, since the low embankment could not provide enough protection. The surface material varies from pure sand to clay. These clay deposits are associated with the dried up parts of the flood-channel.

This bar is settled by Biharis who have migrated to it and by local residents. Initially, a mango orchard owned by locals was probably forcibly occupied by Biharis but ultimately the Biharis purchased land from the locals. There is a striking absence of Bangladeshi refugees. It must be mentioned here that the number of refugees in the riverine sandbars decreases noticeably as one approaches Barddhaman town. It may also be noted that the number of Biharis increases simultaneously.

This tract is intensively cultivated by locals and Biharis as well. Cattle rearing is an important occupation and is generally pursued by Biharis. Fresh sands are quarried and lorries ply right up the main thalweg. Unlike those in other sandbars, the Fakirpur settlement is not linear. Its shape is rather amorphous towards Idilpur and Kathgola ghat. There is another group of settlements towards Sadar ghat. Siting of settlement is controlled less by morphometric property of the bar than by connectivity with the town of Barddhaman. Between these two enclaves there is an extensive area yet to be settled.

6.3.13 Shrirampur to Chaitpur

Longitudinal marginal sandbars between Shrirampur and Chaitpur are within Shrirampur, Hatsimul, Kanthalgachi and Chaitpur mouzas under the police station Barddhaman. The nearest railway station is Saktigarh. Barddhaman is the nearest town.

In Dickens's map of 1854, these bars were shown as well defined point bars without any vegetal cover. There were embankments on the left and right as well. The SOI map of 1919–1920 shows the same bar as grass-covered fragmented bars. From the SOI map of 1969–1970 and 2003 LISS-3 scenes of the IRS-1D satellite the fragmented bars have been shown as a continuous bar with the left bank embankment (Fig. 6.31). Figure 3.11 shows:

i. A dried up channel with the Damodar right bank embankment
ii. Shifting bank lines between 1984 and 1990
iii. Boulder pitching, a protective measure to arrest shifting bank lines
iv. A point bar on the right bank.

This stretch is not settled. The fresh sands are used in two ways, sand quarrying and growing vegetables that require a short growing period. The dried-up channel bed is also used for such vegetables in non-monsoon periods (Fig. 3.11). Growing of vegetables depends on the field capacity of fresh sand which is usually low. On the western side there is a small settlement. Contemporary land use shows how a flow resource has been replaced by fund resources.

6.3.14 Chaitpur to Kalinagar

The area is situated above Palla where the Lower Damodar takes a sharp southerly bend. It is located to the south-east of Barddhaman. The nearest railway station and town is Barddhaman. The Dickens's map of 1854 shows embankments on both sides. The SOI map of 1919–1920 shows the left bank embankment only but the SOI map of 1969–1970 and 2003 LISS-3 scenes of the IRS-1D satellite shows double embankments on the left. The thalweg is on the left (Fig. 6.31).

The area has been resurveyed by the Irrigation and Water Ways Department of West Bengal. The layout plan (Fig. 3.12) of the Damodar near Fatehpur village under Jafrabad mouza shows the following features:

i. Towards east the bank line has shifted between 1978 and 1985
ii. The thalweg is still on the left side
iii. Several sandbars have been formed which are only 27 m above the the water level at their highest points.

From the field survey it is observed that the left side has become erosion-prone; therefore, protective measures such as boulder pitching have been taken since 1990.

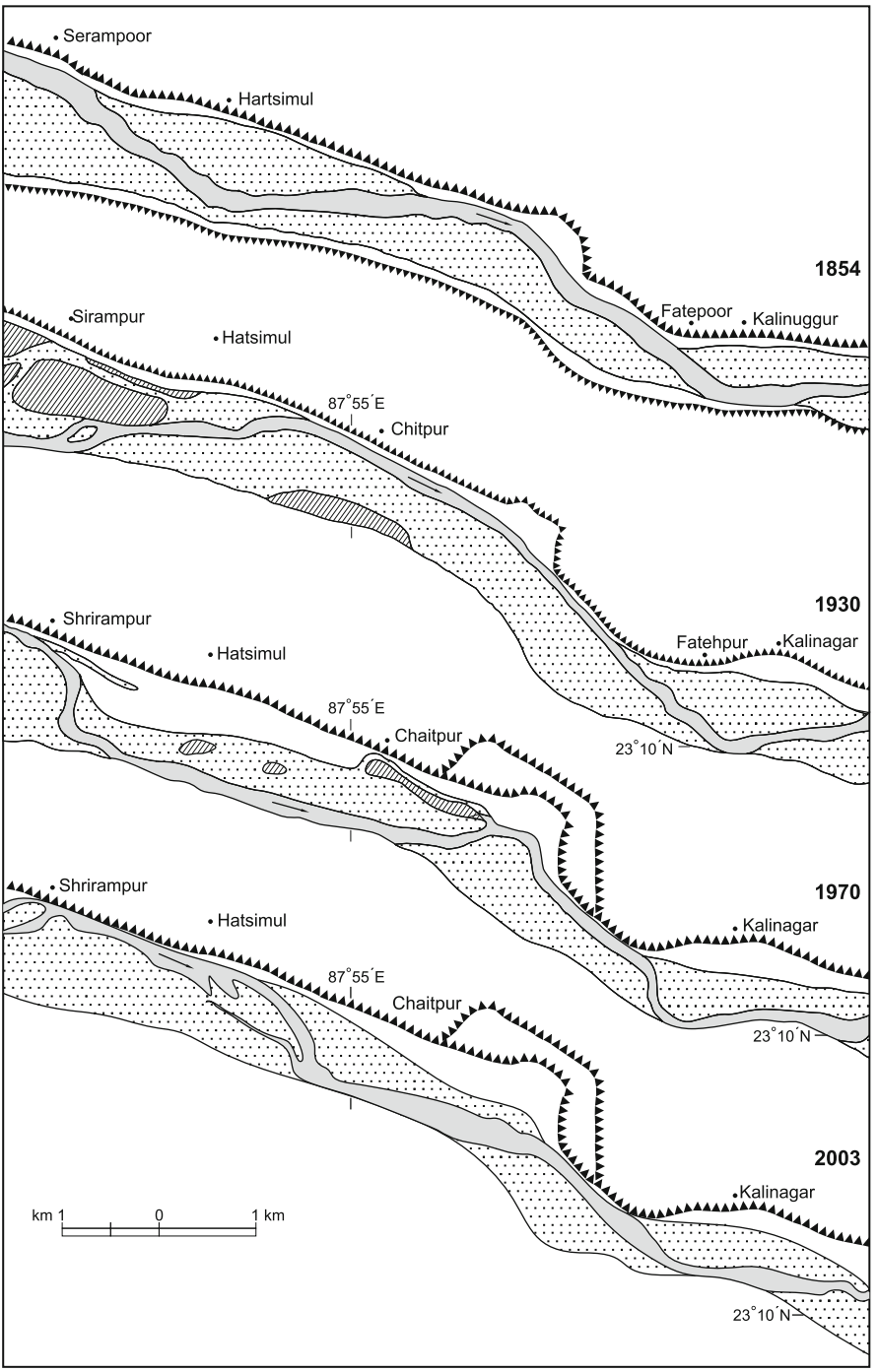

Fig. 6.31 Changing river bed morphology: Shrirampur to Kalinagar
The map drawn from the Survey of India (SOI) maps of two series (73 M/16, 1: 63,360, 1: 50,000), a 2003 LISS-3 scenes of IRS-ID satellite, and 1854 map of Dickens is shown

On the unprotected right bank there was a spill channel locally known as Mohanpur Hana but the off-take point of this spill channel has been sealed off to protect the adjacent riparian tract from floods. The sand bars are yet to be stabilized; therefore, no permanent settlement is found. Locals from adjacent villages use the riverbed between the bank line of 1978 and 1985 for paddy and potato cultivation. Mustard is also grown. Fresh sands from mobile sandbars are quarried by the locals.

6.4 Human Perception, Adaptability and Resource Evaluation in the Riverbed

Sandbars that were perceived as unproductive by the local agrarian community were seen quite differently by refugees due to their distinct position in the social space. Although there are fewer floods in the post-dam period, sandbars still get inundated, at least partially, whenever excess water is released from the reservoirs. The refugees have accepted this flood risk and have taken some pragmatic measures in their own land use system which is flexible and adjusted to the flood-prone micro-environment. At present all available space on the sandbars is being used objectively and rationally. As human perception and the appraisal of environment has changed, the concept of resource evaluation has widened (Bhattacharyya 1997, 1998, 2009).

In Gangtikali, there has been a shift of resource base from geological to agricultural with a consequent change in settlement site. As the occupiers are Biharis, their preferred foods, wheat and maize, are the most important crops grown on the island. Because of higher elevation, release of water from the Panchet is not considered hazardous. Instead, it raises the water level, thus helping to lift irrigation.

Flood risk is low in the main area of Telenda mana, as the main flow of the Damodar is far away from the settlement. Wet rice and jute were introduced first as major crops, followed by two other important crops, wheat and potatoes. On the periphery of Telenda mana, quick-growing additional crops are grown on the nutrient-poor fresh sands which are exposed after lowering of the river water level. The riverbed of the Gaighata is used for additional crops. A new Vivekananda colony has developed towards the Panchet side.

The sandbar in Damodar Char Mohana is highly inundation-prone. Land use on this bar is flexible with spatio-temporal variations in land use attuned to spatio-temporal variations in inundation. Settlements and perennial tree crops are to be found on the highest part of the bar. Inferior crops and vegetables are grown on the flood-prone peripheral zone. The concept of flood zoning has been applied here at a micro level. Crops grown vary from cereals to cash crops that include potato and chilli. Extraction of sands from the dead channel on the left has deepened the channel, posing a threat to the stability of the bar. Refugees on this bar have been granted land deeds despite the vulnerability of the area.

Ramakrishna Palli, Pallishri Sqatters' colony, and Sitarampur Mana are situated on a marginal bar, a former active riverbed that has nearly merged with the mainland

due to the southward shift of the main Damodar. A few decaying, drying channels, including the previous thalweg, are still visible. Here, inundation risk is low due to controlled release of water and the emergence of a transient bar south of the main bar. This bar was inundated but not totally destroyed in the 1978 floods. Surface materials in the bar vary from sand to clay deposits in the dried up channels. Along with rice and mesta, different types of vegetables are grown in Ramakrishna Palli, Pallishri, and Sitarampur Mana.

Bara Mana, the largest alluvial sand bar in the culturally defined Lower Damodar, has grown in size since 1920 and this enlargement has become more noticeable since 1957. Bank erosion is a perpetual problem in Bara Mana, particularly towards the barrage and weir side. The main thalweg is on the right. Other channels have either dried up or are in a moribund state. The 1978 flood submerged the bar but did not totally destroy it. Every inch of land in Bara Mana is put to agricultural use with crops varying from traditional rice and jute to different types of pulses, oil seeds, vegetables including potato, and mulberry, a perennial tree crop. Land use is flexible and flood zoning is attuned to micro relief variations (Figs. 6.14 and 6.16). Additional crops of different types of gourds and melons, including "khero" which requires little care and can be grown profitably on nutrient-poor fresh sands, are grown on the inundation-prone peripheral zone. Settlements, mulberry plantations, and floriculture are sited on higher ground. Settlement sites, structures of individual huts, and plans of individual rooms are adapted to the flood susceptibility of this mid-channel bar. Changes in settler relations with local residents, strong market forces and granting of ownership rights have influenced land use and contributed to changes in riverbed form, processes and materials.

Being situated within the Rhondia weir, the Rangamatia-Kenety mana bar is extremely inundation-prone. Between 1920 and 2003 the bar has shown shape distortion due to size reduction and enlargement of the bar in different parts. The bar was submerged and severely damaged during the 1978 floods. The thalweg has shifted to the south but retains its initial braided channel pattern. The R.K.N. bar contains some permanent pockets of bank erosion.

Surface materials vary from sand to clay. Locals migrating from the districts of Hooghly and Medinipur after the floods of 1978 have changed the population composition of the refugee dominated R.K.N. Mana. Rice and jute have been extensively cultivated on the leveled inner zone from the very beginning of habitation. Due to accessibility to Sonamukhi (Bankura) and Panagarh (Barddhaman), almost all types of vegetables including highly perishable leafy vegetables, are grown. Potato cultivation has been introduced by migrating locals. The inundation-prone peripheral area is usually left fallow. Linear settlements of refugees on higher ground stand in contrast with the isolated homesteads of local migrants. New settlements have sprung up in the south, far away from the permanent bank erosion-prone area. Movable bamboo structures are used to build individual houses that are constructed on higher plinths. People here believe that Rangamatia dykes, a local effort, may reduce bank erosion and help in partial reclamation of inundation-prone land (Fig. 6.22).

From a group of sandbars in 1920, the Fatehpur and Kasba Mana has become a continuous longitudinal bar. Noticeable size reduction has been observed between 1957 and 1985 due to severe bank erosion during the 1978 flood. The thalweg has shifted to the south. There is a feeble channel between Beloa, Rupuisar and Fatehpur, Amritapara, Bhesia. The northern part of the sandbar has nearly merged with the mainland. After 1957, a portion of the mobile riverbed, locally known as Chhita Mana, became stable southeast of the Kasba Mana. Bank erosion is still a noticeable feature towards the right bank. The sandbar is settled by Bangladeshi refugees, Bihari refugees, and local residents who have migrated from the Hooghly district. Wet rice and jute were introduced to Fatehpur and Kasba Mana first by the Bengalee refugees. Decaying drying channel beds are used for rice culture. Since 1970, the extension of irrigation facilities using shallow tube-wells has made it possible to grow HYV varieties. Additional crops such as different types of cucumbers and melons are grown on the periphery of the bar. A small canal, diverting water from the Damodar main canal, has been dug in the Kasba Mana. Perishable vegetables are not grown due to lack of transport facilities. The most important cash crop on this sandbar is the potato, which was introduced by migrating people from the Hooghly district. The early settlement on Fatehpur and Kasba Mana was on the southern side of the bar. The present settlement has shifted northward. Like other bar settlements, the Fatehpur and Kasba settlements also show a marked linearity.

Between Chhita Mana and Panchpara the Lower Damodar has thrown several flood channels on the right bank. Some of the detached flood channels look like a string of linear lakes. The left bank embankments may be observed from Silna. There are double embankments in places.

The Damodar is very narrow near Panchpara because the riverine alluvial bars have merged with the mainland. The riverbed is almost choked with mobile sandbars and the thalweg has shifted to the north. The river is almost fordable from November to June. Rice is the main crop and the only cash crop is the non-perishable potato since there is no easy access to markets. Vegetables are grown for home consumption only.

Majher Mana, a mid-channel bar, is growing to the west and the north. The eastern-most end of the bar was severely affected during the 1978 floods. An enormous quantity of sand was deposited on the western end. Majher Mana is separated from the previous Baseepoor (present Lakshmipur Mana) by a feeble channel. This alluvial bar is dominated by refugees. Land use is flexible and the concept of flood zoning has been applied. Wild grasses or additional crops of low value are grown on the periphery. Mulberry plantations are found on the highest elevations. Social forestry is practiced in the northeastern part of Majher Mana. The 1978 flood deposits are being reclaimed for rice, jute and additional crop cultivation.

The Satyanandapur–Kalimohanpur sandbar has always been flood-prone due to unstable behavior of the Banka nala and so has double embankments of considerable height. The bar is susceptible to bank erosion towards the south. The main thalweg to the right is not very deep. The settlers on the Satyanandapur–Kalimohanpur bar are Bengali and non-Bangladeshi refugees together with a few local residents. Rice is

the main crop. Potato and other vegetable cultivation have recently been introduced after the extension of bus services from Udaypalli to Belkash.

Gaitanpur is a flood-prone bar that is at risk from the seasonally activated flood channels. It is settled by migrated Biharis and locals with Biharis being the dominant group. Population composition has changed recently due to inclusion of Bangladeshi refugees. Although agriculture is the main occupation, cattle rearing is given equal emphasis due to demand for milk in Barddhaman. Potatoes, vegetables, and oil seeds have been introduced recently. Floriculture, introduced in 1990s is becoming popular now. The bar was severely damaged during the 1978 floods and its size was reduced. Extensive areas were covered with sands which used to support only grasses until 1990. These deposits have recently been put to agricultural use with the application of an indigenous technique. Despite proximity to Barddhaman town, Gaitanpur, like other mid-channel bars above the Rhondia weir, is not well developed.

Fakirpur is a marginal bar with an active flood-channel towards the north. Due to severe bank erosion to the north, boulder pitching measures have been adopted. The bar is populated by Biharis and locals. Cultivation and cattle rearing are two of the main activities. The bar is noted for sand quarrying. Settlements are located near the main transport route. The settlement pattern is amorphous.

From Chaitpur to Kalinagar, the left bank is shifting in character. Boulder pitching is used to arrest these shifting bank lines. Vegetables are grown in dried-up channels. Riverbed sands are extensively quarried.

The stretch of the Damodar between the Maithon and Panchet reservoir and Barsul-Chanchai is not very much differentiated in terms of contemporary riverbed morphology and bed materials, particularly below the Durgapur barrage. Alluvial bars, mobile, semi-mobile, or relatively static, are general features of the riverbed. Bed materials are fresh sands or sandy loam. But the riverbed landscape, shaped by functional relations between the riverbed and its occupiers, shows diversity at a micro level. Socio-cultural, economic, and political backgrounds of riverbed occupiers have been reflected in the land use practices. Wheat is the main crop in Bihari-dominated sandbars like Ganglikali and Gaitanpur. Rice and jute are two important crops in Bengali refugee-dominated settlements. Bara Mana and Majher Mana show all stages of agricultural development. These two riverine bars are also examples of application of the concept of flood zoning. With increased social mobility and access to local markets, capital-intensive and environ-sensitive crops such as mulberry have been introduced on higher parts of the alluvial bars. Granting of ownership rights in recent years has played a crucial role in land use practices. Refugees take more care to fortify their resource base by applying indigenous techniques. Settlements like Rangamatia and Bara Mana have reached a level of self-sufficiency. This has been possible due to their keen perception of hydro-geomorphological parameters of the controlled river. The stretch between the Panchet Maithon reservoirs and Barsul Chanchai has become less hazardous and more resource-rich with the mitigation of annual flood discharge. Here, risk is capitalized as a resource and long-term benefits have overshadowed the short-term risk (Bhattacharyya 1998, 2009).

6.5 Disaster Reduction Measures and Survival Strategies

The migrant community discovered these riverbed char lands as there was no competition for these sandbars and here they could have an independent existence. They started to colonize these uncharted terrains whose resource potentialities were not identified by the local people. These people with their sense of vulnerability analyzed the physical space more objectively and rationally and looked at it as a challenge to their independent existence. They were forced to live within such a closed system, but this system enabled them to assess the physical parameters of flood more objectively and to adopt innovative measures to reduce hazard loss. Based upon their knowledge of river stages, they have matched land use at fine scales to flood experiences, applying a concept of flood zoning to the riverbed. Every available space has been utilized rationally and judiciously. The inundation-prone peripheral zone of individual bars is left fallow. The wild grasses that grow on sandy soil are used to make rope and some other crude house hold commodities. The next zone is utilized to grow quick-maturing inferior types of vegetables and fruits like bitter gourd, cucumber, and water melons. On relatively safer areas they grow cereals, vegetables like potatoes, cauliflowers, radish, tomatoes and many other leafy vegetables, cash crops like oilseeds, Jute, sugarcane. In some of the bars, mulberry cultivation has been introduced for cocoon-rearing. Perennial fruit trees are common on the highest parts of the bars. Moreover, they often take the risk of growing capital-intensive vegetables even in the most vulnerable tract sas they have ready markets in Durgapur, Panagarh, Sonamukhi and Barddhaman.

The settlements are strikingly linear on the crests of the convex bars. Investment in the construction of houses is very low. As mud is not available locally, the houses are made of locally available jute sticks and bamboo. Almost each house has an upper shelf where they can keep their valuables and take refuge during floods. During high floods they move to the mainland with their mobile population. Spurred by restricted social and economic mobility and sometimes political constraints, islanders have learned to adapt to their vulnerable environment. They have accepted flood risks and have taken some pragmatic measures in their own land use system (Bhattacharyya 1997, 1998, 2008b). They have learned to undertake damage mitigation measures for flood management using an integrated approach. Kundzewicz and Kaczmarek (2000) stated “More disaster-conscious societies need to be built with better preparedness and safe-fail (safe in failure, i.e., system that fail in a safe way), rather than unrealistic, fail-safe (safe from failure, i.e., systems that never fail) designed systems. Since a flood protection system guaranteeing absolute safety is an illusion, a change of paradigm is needed: it is necessary to live with awareness of the possibility of floods”. Thus, looking on the bright side of the floods, they have learnt to underestimate the danger of living in a flood-prone micro environment, therefore, the flood reduction measures specially non-structural measures adopted by these refugees often poses challenges to the technology and capital-intensive measures taken by the governments (Basu and Bhattacharyya 1991; Bhattacharyya 1994, 2008b).

River communities have developed adaptation strategies to live in such a marginal environment. Some of their survival strategies include changing crop patterns, constructing flood resistant buildings on higher ground, planting trees, building settlements on higher plinths above river water level, building inundation-proof structures, and evacuating the areas during high floods. They are also building several dykes to protect their sandbars from erosion. Although the education level of the majority of people living on the sand bars is very low, they are taking measures similar to land use planners; evaluating proper land use in terms of both the potential flood risk and the beneficial natural attributes of the riverine environment (Bhattacharyya 2008b).

Settlers have a definite plan of action which they implement at the time of need and the Damodar river beds are gradually being legally occupied (Bhattacharyya 1998, 1999, 2008b). The main attraction of this "living with floods" approach is that it produces benefits from the normal floods whilst reducing the risks during abnormal hazardous events (Bhattacharyya 2002). To reduce flood hazard, the local population in these sand bars either migrate temporarily to a safer zone or migrate permanently if the economy permits. Instead of fortifying their environment, they depend on aid agencies during calamities. But the same group, when uprooted and attaining refugee status may reject a dole-sustained existence and colonize in barren areas. In the process of colonization they modify and fortify the vulnerable tract and gradually expand the local resource base to reduce hazard loss (Bhattacharyya 1991, 1999).

6.6 Flood Zoning in the Charlands/Sandbars

At the initial stage, the migrant community started devegetation of the sandbars. As they were from the farm sector, they began to perceive the agricultural potentiality of the sandbars and adapted themselves to such tracts with their wet rice culture. "In the past we used this tract as grazing ground. Falling leaves and animal droppings enhanced fertility of the sandbars" – "Amra aage ai jaygay goru mosh choratam,. oder gobor ar pocha patay ai jomir urborota bere gelo" said Bolai Paik, a well known farmer from Bara Mana. Land use in the sandbars follows the dictate of micro-relief. Where habitation is not possible due to the low height of the bars, sand quarrying has become a dominant activity. Moreover, settlers often take the risk of growing capital-intensive vegetables even in the most vulnerable

Fig. 6.32 Generalized crop calendar – a model
The settlements, dotted with perennial crops, floriculture, cocoon rearing mulberry plantations, potato cultivation are sited on the highest part of the sand bars on about 8–10 m above the riverbed.

The zone next to the highest elevations (3–8 m) is devoted to the cultivation of cereals and important cash crops. The Bangladeshi refugees have introduced chilly as an important cash crop to these char lands.

Fig. 6.32 (continued) Fast-growing vegetables and fruits such as poira or additional crops are planted on fresh sands near peripheral zone on about 2–3 m from riverbed level with the lowering of river water level. Height mentioned here varies in different char lands or in same bars according to the differences in width and height in particular char land

tract, as ready markets are present in Barddhaman and Durgapur. In these sandbars the groundwater table is high and a crop is assured with irrigation through shallow pumps. Present land uses such as the site and structural pattern of settlements, site and selection of crops, and mode of irrigation water are very carefully attuned to the best utilization of the local resource base (Basu and Bhattacharyya 1991; Bhattacharyya 1998, 2008a, 2009). A generalized crop calendar model is shown (Fig. 6.32). The crop calendar is finely adjusted to match the flood-prone micro-environment.

6.7 Contemporary Riverbed Characteristics: Barsul Chanchai to Paikpara Settlement

Alternate point bars with a narrow channel are the primary characteristics of the riverbed below Barsul-Chanchai. The SOI map of 1969–1970 shows only the left bank embankment, as the right bank embankment has already been removed. Instead, on the right bank, there are several spill channels of which Nagra hana spill channel merits mention. The riverbed characteristics of the Damodar and its main spill channel, the Muchi hana are shown (Fig. 3.7). Notable features include the fact that the main Damodar is narrower than its spill channel, the Muchi hana, which appears to be a braided channel. The Begua hana connects the Damodar with the Muchi hana which then takes the new name of the Kanki-Mundeswari. The Amta channel is the continuation of the Damodar. The left bank embankment on the river is shown.

The Lower Damodar takes a sharp southward turn from Barsul-Chanchai in accordance with the regional slope of the Bengal delta. Geologically and geomorphologically this section is distinctively different from the section above Barsul-Chanchai. The sudden southward bend is attributed to the lineament characteristics of this part of the Bengal basin. The lineament analysis of the Bengal basin, as inferred from Landsat imagery, shows ten major lineaments and the Damodar lineament is one of them (Agarwal and Mitra 1991). Some other tributaries of the Hooghly Bhagirathi, such as the Mayurakshi, Khari and Banka, show similar trends and these trends are also explained in terms of lineament characteristics (Niyogi 1978).

Geomorphologically, all the rivers show deferred tributary junctions. Had the east west trend of the Lower Damodar continued, the river would have joined the Hooghly far north of the present Falta outfall. It was mentioned before, while tracing the flood history of the Lower Damodar, that this Barsul-Chanchai section is the area from where several distributaries were thrown in the historical past and some of which became the main channel in a specific period. Those channels have dried up, but large and small natural levees and the Palaeo Sub delta (Fig. 6.33a–c) are still to be found (Niyogi 1978; Agarwal and Mitra 1991). From Barsul-Chanchai there has been a gradual diminution of cross section i.e., reduction in the width of the natural river and overall shrinkage of the channel. This section is also conspicuous by an

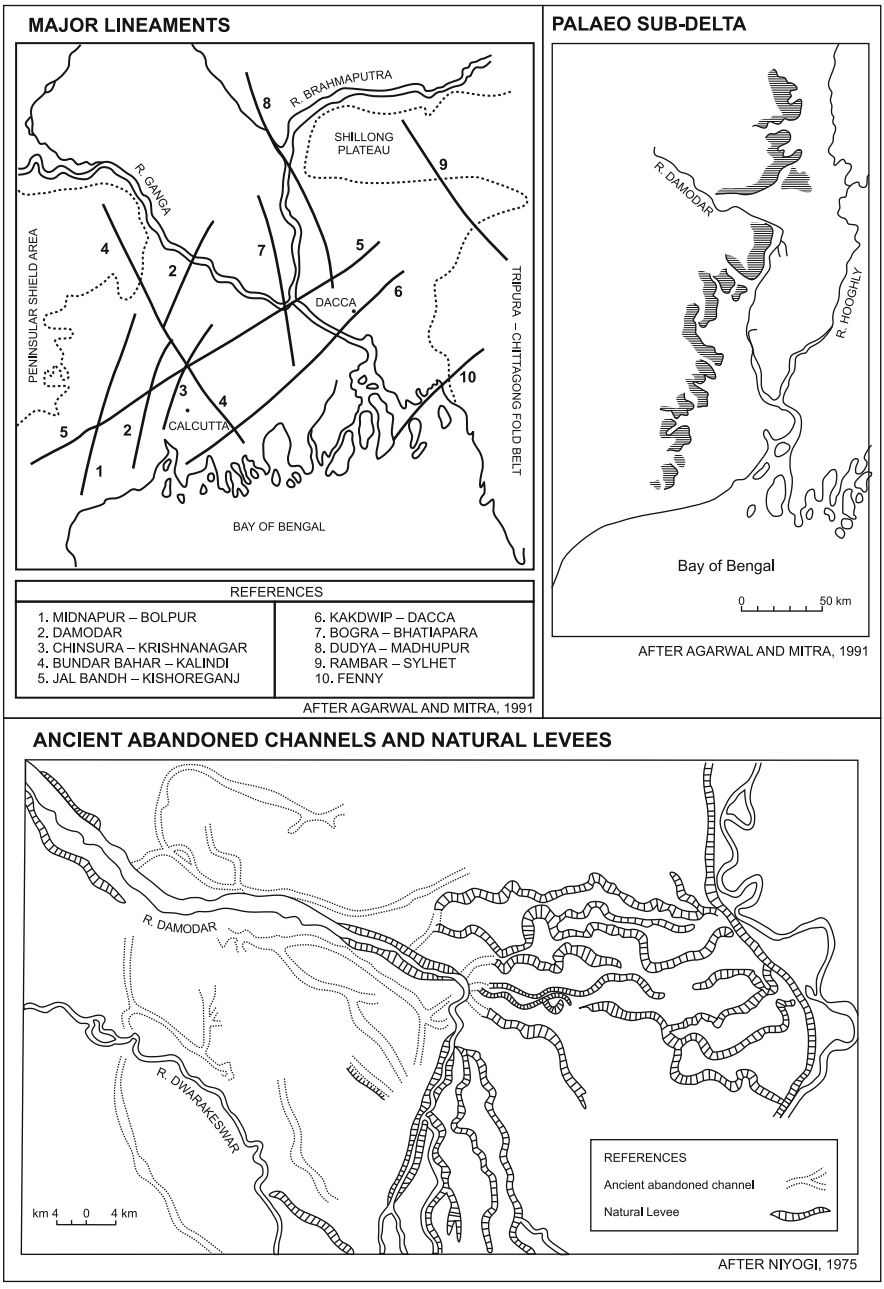

Fig. 6.33 Some Geomorphological aspects (a) Major lineament, (b) Ancient abandoned Channels and Natural levees, (c) Palaeo sub-delta. Source: 6.33 a, c. After Agarwal and Mitra 1991; 6.33b. After Niyogi 1978

absence of prominent mid-channel alluvial bars, a significant feature above Barsul-Chanchai. Treatment of the Lower Damodar below Barsul-Chanchai is separated not only on the basis of geological and geomorphological characteristics but also on the basis of settlement characteristics. This is the section where riverbed occupiers are not refugees.

6.8 Land Use Planning: Barsul Chanchai to Paikpara Settlement

Paikpara is a very old settlement in the Barddhaman district. It was previously known as Panchpara. In Bengali "panch" means five and para means locality. From the name Panchpara it appears that the settlement probably consisted of five localities. Paikpara is sited at the bifurcation point of the Muchi khal (hana) and the Damodar (Fig. 3.8). It is under the police station of Jamalpur of the Barddhaman district. The nearest railway station is Memari.

Paikpara is an oval-shaped village. The maximum length and width are 1.6 and 0.96 km respectively. The surface material is sandy loam. Initially, Paikpara (previously Panchpara) was sited on the right side of the river Damodar and the present site was shown as a point bar as is observed from Dickens's map of 1854. This map does not show any spill channel (Fig. 3.8). In the mid-nineteenth century, the right bank of the Damodar was almost open due to the removal of 32.19 km of the old embankments. But as has been mentioned previously, the left side was completely chained by high continuous embankments. This section has become very significant from a socio-economic point of view. Opening of spill channels or flood channels is a natural process at the delta stage of any low-gradient alluvial channel. In all probability, the Muchi hana was formed as a natural spill channel below Jamalpur. It is also possible that the removal of the right bank embankment helped in opening up spill channels. Such spill channels often develop as a consequence of neck cut-off. The Muchi hana has been referred to as Muchi *Khal* in the cadastral map of Paikpara. The term Khal is often used for an artificially cut channel. The local residents believe that the Muchi hana is a human-made channel. Such artificial cuts are common in the Mississippi below the Arkansas River. Schumm (1977) has referred to the dramatic shortening of the Mississippi River after 1929 as a result of artificial cuts-off. Thus, by 1856, the Muchi hana was a well-defined flood channel. In the map of 1957 the Muchi hana is shown as a wide braided channel. If 1,416 m^3/s of water passed through Rhondia in 1957, the entire discharge of the Damodar used to flow through the Muchi hana. At higher flood stages, a part of the discharge, though small, went into the Amta Channel (DVC 1957, V-I & V-II; Bhattacharyya 1998, 1999–2000a).

Regarding the opening of the Begua hana, the DVC report of 1957 mentions that a transverse dyke was put up across the Muchi hana in order to revive the old Damodar channel and to close the Muchi hana (DVC 1957, V-I). This measure, however, proved ineffective, helping, instead, to open the Begua hana (DVC 1957, V-I).

The general opinion is that that the opening of Begua hana is anthropogenic and the main purpose behind digging the Begua Muchi channel was to lessen pressure on the main Damodar and to save the settlements and the railway line on the left from flood havoc. The Muchi Begua is known as the Kanki further down and as the Mundeswari when it enters the district of Hooghly. The Begua channel was so narrow that it used to look like a village *nala* (brooklet) but within 20 years it has become a wide river. It is also believed that because of the widening of the Begua, flood propensity in an otherwise flood free area has increased. In the month of August 1993, extensive areas were flooded here (Bhattacharyya 1999–2000a). Paikpara is now bounded by the Muchi hana on the right side and the old decayed Damodar on the left. At the point where Muchi hana bifurcates, a high sand bank completely shuts off the flow of water into the Damodar and the newly scoured bed of the Muchi hana becomes lower than the sand-filled bed of the Damodar (Bose 1948; DVC 1957, V-I). As a result, the maximum discharge, i.e., more than 80% flows through this hana (DVC 1995). Paikpara now looks like a mid-channel bar (Fig. 3.8).

Paikpara is settled by local Bengalis. They are more or less undifferentiated in terms of religion, caste and occupation. The area between the Muchi hana on the right side and the old Damodar on the left is a region of continuous bank erosion and depopulation. In 1961 the total population of this area was approximately 811 and the total number of household was 115. This has been decreasing due to excessive bank erosion, especially on the left side of the Muchi hana. In 1971 the total population of this area was 455. In 1981 the total population decreased to 418 and the number of houses was only 65 (Census 1961, 1981). The population is still on the decline (Bhattacharyya 1999–2000a). In 2002 there were about 50 houses and the total population fell to 383.

Hydro-geomorphological characteristics strongly influence riverbed land utilization in Paikpara. Because of decreased flow, the Damodar riverbed, barring a few months in monsoon, looks like a string of stagnant pools. Within these stagnant pools, clay particles are deposited due to very slow vertical accretion and the low settling velocity of clay particles (Morisawa 1968). Clay-rich soil is mixed with sandy soil in order to increase water retention. The sandy bed load is thus put to agricultural use and water from stagnant pools is used for irrigation.

Crops grown in the Paikpara area are rice, potato, and oilseeds. Clay deposits on the riverbed are used for cultivation of wet rice. Arum is another important vegetable grown in Paikpara. Another noticeable feature of riverbed land utilization here is the cultivation of gamma grasses in order to arrest flood propensity. During monsoon, or if there is a back rush from the Muchi-Begua hana, the old Damodar looks like a perennial river. Water is then lifted from the river to irrigate the interstream areas.

There is a sand quarry on the Muchi hana near Fetehpur. The Bishalakshi dah i.e., natural lake or depression, on the Muchi hana is shown in the map surveyed in the year 1929–1930 (Fig. 3.8). Such depressions, locally known as “daha” are usually formed during floods due to scouring action of the water. Successive floods deepen these depressions which ultimately become components of the landscape. This depression was probably created during the floods of 1913. In the course of

time this depression was filled up by sands as is observed from the SOI map of 1970. What was once a flow resource has now become a fund resource that is utilized for sand quarrying. Incidentally, it may be mentioned that at Similagarh and Pandua near Barddhaman, paleo channels of the Damodar were discovered by chance (Mallick and Bagchi 1975; Fig. 6.33c) and fertile agricultural lands were either sold or leased out for sand quarrying. Due to gradual deterioration of the physical and social environment, the Government of West Bengal has put a ban on quarrying activities since 1980 but sand heaps are still visible in that area. The sand quarries of Paikpara are owned privately, though revenues are collected by the government. Coarse sand is found below 0.91 m up to 1.2 m and is sold at Rs. 2,000 (1 US dollars = 45 Rs.) for every truck. Fine sand is sold at Rs. 225 for each truckfull. The trucks carry the sands to Calcutta. Price behavior of different types of sands indicates that sands are no more only fundamental entities but also important geomorphic resources and resource potentialities that have been enhanced, due to the nearness to Kolkata, where demand for sand is high for obvious reasons.

Fishing was also once an occupation of the people of this village. Some stagnant pools in the decaying drying main Damodar used to be utilized as fish ponds. Obstruction through minor control structures, however, has significantly reduced the fish population. Paikpara is approachable from the Jamalpur side. Cycles, rickshaws, and van rickshaws ply on the left bank embankment. During dry months the Damodar is fordable. During the monsoon it is navigable. The Begua-Muchi hana is navigable throughout the year and a bamboo bridge is found on the old Damodar.

Paikpara shares one of its characteristics with Gangtikali, the first settled bar below the Panchet reservoir. In Gangtikali there was a change in settlement site with the change in resource base from coal mining to agriculture. Change in the settlement site in Paikpara is due to truncation of an agricultural resource base on the one hand and emergence of a new resource base on the other (Fig. 6.34). Before the opening of the Begua-Muchi hana, the Paikpara settlement was on the left, away from the Damodar. But the old settlement site became vulnerable due to problems of bank erosion on the "hanas" and the settlement shifted towards the east where resource potentialities of the riverbed have increased (Fig. 3.8). This type of migration from west to east is thus partly ecological and partly impelled (Spencer and Thomas 1969; Bhattacharyya 1998, 1999–2000a). The people at least had some choice regarding when to migrate and where to migrate. Unlike refugees, the locals are more mobile on the social space.

Paikpara is still not free from flood havoc, as the cadastral map shows in the transverse alignment of plots. The far away Durgapur barrage also exerts its influence on the present settlement site. If discharge from the barrage exceeds 2,832 m^3/s, the area gets flooded. As a result, depopulation has become a common characteristic in Paikpara and the financially strong locals have no difficulty purchasing land outside the area.

Paikpara attained the status of a mid-channel bar due to opening of the Muchi-Begua hanas. Similarly, a few other overbank settlements became riverbed settlements due to construction of the left-bank embankment. Harogobindapur is one of

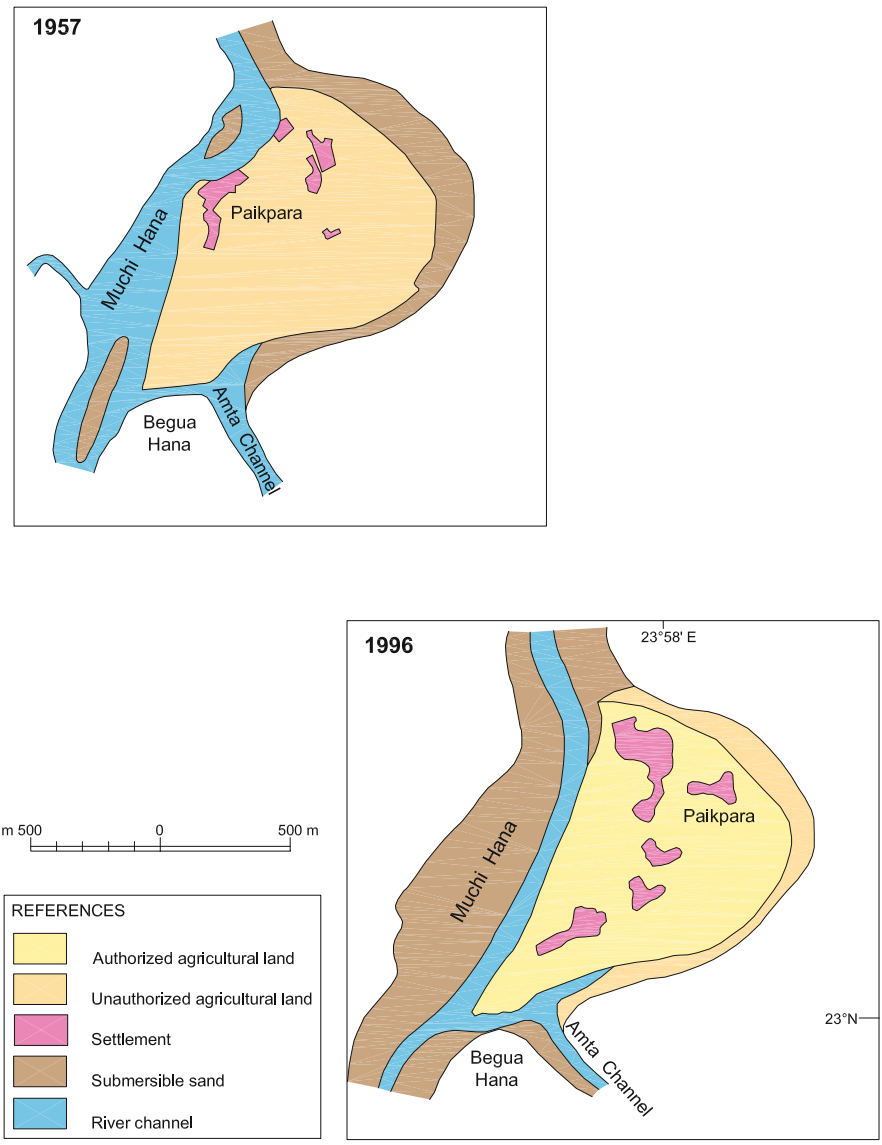

Fig. 6.34 Changes in cultural landscape of Paikpara
Map prepared from Paikpara mouza, 2003 LISS-3 scenes of IRS-ID satellite and field survey

them, protected by embankments on the left and the decaying drying Damodar on the right (Fig. 3.8). The main crops here are wet rice and potato. Despite protection provided by the left bank embankment, the agricultural landscape is less diversified in Harogobindapur. The embankments are lined with energy plantations and they form an important resource base for the riverbed occupiers.

6.9 Changing Resource Status from Flow Resource to Fund Resource

Paikpara is an example of changing of the location of a resource base subsequent to a geomorphic threshold. A neck cut off, known as Muchi hana, is the threshold which has brought about a series of changes. The opening of the Muchi-Begua hana has transformed an overbank settlement into a mid-channel settlement. What was once a part of the mainland is now a part of the riverbed. Here the Damodar bed has changed its resource status from a flow resource to a fund resource. The main Damodar has nearly dried up and now looks like a chain of stagnant pools. The Begua Hana has assumed the dimensions of a river and causes floods in flood years. The interstream area between the Damodar and the Muchi Hana is prone to bank erosion from both sides. Sudden release of water from the upstream barrage and reservoirs has increased bank erosion problems. Paikpara was safer on the western side, but now the western side has become hazardous due to bank erosion which has led to depopulation.

Compared to the refugee settlements above Barsul-Chanchai, Paikpara, settled by local residents, is less prosperous. Harogobindapur, like Paikpara, was also an overbank settlement but is now a riverbed settlement because of the left bank embankment. The settlement is shifting towards the east since the embankment is considered to be a safer location. The riverbed in this area is used for raising cereals, vegetables and oil seeds. Gamma grasses are grown in flood-prone parts of the bed. Excess water from the old Damodar is pumped out and used for irrigation. Riverbed sands are quarried to be transported to Calcutta. Strip plantations on the embankment form an important resource base.

6.10 River Bed Characteristics: The Amta Channel

Below Paikpara, the controlled Lower Damodar takes a new name, the "Amta Channel" (Fig. 2.1). As the main flow (more than 80%) passes through the Mundeswari (DVC 1995; Bhattacharyya 2002), the Amta Channel looks like a rivulet chained with embankments. The width of the channel never exceeds 1 km. The channel is conspicuous by an absence of mid-channel bars, a significant and important within-channel feature in the upper sector of the Lower Damodar. Bars in the Amta Channel are longitudinally-oriented narrow marginal bars.

The stretch between Paikpara and Bahir-Aima, the farthest settlement near Falta outfall, includes 170 mouzas and comes under the police stations of Jamalpur of the Barddhaman district and Dhaniakhali, Tarakeswar, Jangipara and Pursura of the Hooghly district and Udaynarayanpur, Amta, Bagnan, Uluberia and Shampur police stations of the Howrah district. The nearest railway station and town is Uluberia.

The total length of the Amta channel is 107 km. The thalweg of the Amta channel is extremely narrow compared to that of the Kanki-Mundeswari. Hydraulic sinuosity index of this Amta channel is 5.71 and topographic sinuosity index is

94.29. The river is shallow and fordable at many places. There are embankments on both sides; the right bank embankment is closer to the river. Between Habibpur Chaitanyabati there are double embankments. At Chaitanyabati and Nachhipur, the main left bank embankment is 1.5 km away from the river, indicating the flood propensity of this side. Heights of the embankments vary from 4 to 5 m. The lower part of the Amta channel is affected by tides but the tidal influence has been restricted due to the Ulughata sluice. The Amta channel can be divided into two sectors. Sector-I extends from the Kanki-Amta bifurcation point to the Ulughata sluice and Sector-II extends from the Ulughata sluice to the Falta outfall. Below the Ulughata sluice, the Amta channel has almost become a defunct channel (Fig. 2.1, Plate 6.14). The natural Amta channel is very narrow but the riverbed within embankments is very wide in many places as has been mentioned above. There are few settlement sites in this riverbed. These settlements are extensions of the mainland settlements. Residents are locals with Hindus dominating. The Amta riverbed is devoid of refugee settlements. The most important settlement is the Bahir Aima.

6.11 General Land Use in the Amta Channel

The main food crop in the riverbed is wet rice, while the main cash crop is potato. Other crops are extensively grown with the help of well and tube well irrigation, but tube well irrigation is restricted to a very few settlements such as Kumral, Nachhipur and Mirzapur. At Habibpur and Chaittanyabati, tank irrigation facilities are available.

Marginal bars from Diwantala to Chhayani Gujrat under Bagnan police station of the Howrah district are used for floriculture. Two types of flower trees are selected, perennial and seasonal. Rose (*Rosa centifolia*) and Hibiscus (*Hibiscus rosa-sinensis*) belong to the perennial group whereas marigold (*Tagetes patula*), chrysanthemum, and cosmos are seasonally cultivated. Here, land elevation, soil texture, and structure, albeit important, are less significant than economic factors. Flowers are a perishable commodity and therefore require a rapid transit system. Proximity to the Jagannathghat, the biggest flower market in eastern India (near the Howrah station), and railways, are the main economic factors behind selection of floriculture in these marginal bars. Selection of rose, hibiscus, and marigold, however, has a socio-cultural significance. Apart from ornamental value, rose, hibiscus and marigold have religious, cosmetic and therapeutic value. Roses are used during Hindu religious ceremonies, and are a sacred flower to Muslims; incidentally the nearby villages have a sizable Muslim population. Rose water is supposed to have therapeutic value. Perfumes are also manufactured from rose. Hibiscus is the most sacred flower among a section of Hindus known as Shaktas who worship the goddess Kali. As a result, there is a great demand for this flower during Dipavali (the biggest festival of India) in the month of October when goddess Kali is worshipped in West Bengal. There is a perennial demand for this flower wherever Kali temples exist. Hibiscus and its leaves are coveted items in the herbal cosmetic industry.

This industry manufactures herbal oil from hibiscus. Bright coloured marigolds have an extensive market during marriage ceremonies of all religions. Marigolds are also required for worshipping Saraswati, the goddess of learning. In the month of February almost all educational institutions observe this festival of worshipping Saraswati. Finally, cosmos and crysanthemum are used for decorative purposes. These economic and social factors – namely, connectivity and market demand – have played a decisive role in the selection of such perishable crops such as flowers in these riverine bars (Bhattacharyya 1998).

Some of the marginal bars along the Amta channel from Diwantala to Ranibhog are noted for making tiles and bricks (Plate 6.15a, 6.15b). Salt-free sandy soil is good for tile manufacturing. The sandy loam soil is mixed with clay soil collected from the surrounding area and is used for making tiles; the period in which this generally occurs is from November to April i.e., in the non-monsoon months. There are a significant number of tile factories in this bar. This sandy loam soil mixed with clay soil is also suitable for making bricks. There are many brick kilns from Diwantala to Ranibhog. The demand for tiles and bricks has increased in urban as well as in rural areas.

Marginal sandbars from Boalia to Garh Chumbak just above Diwantala near Ulughata sluice are used mainly for betel leaf plantations (Plate 6.16, 6.17). Betel leaf plantations last long in clay soil and betel leaves of superior quality are usually grown in clay soil. Here, however, betel leaf plantations are a significant component of land use in the sandy loam soil along the Amta channel. Like floriculture, the size of a betel leaf plantation is also fostered by economic feasibility. There is a demand for betel leaves among Bengalis and proximity to the Kolkata provides a ready market for this perishable commodity.

If we make an observation on the generalized land use characteristics in the marginal bars of the Lower Damodar i.e., in the Amta channel, we notice that vegetables such as potatoes are grown extensively on the marginal sandbars of the Hooghly and Howrah district. In the marginal sandbars of the Howrah district, long melon (*C. Melo Var, Utilissimus*), watermelon (*Citrullus vulgaris*) and cucumber (*cucumis sativas*) are also grown. General land use characteristics of a part of the Amta channel have been shown (Fig. 6.35). Due to drainage diversion by the Ulughata sluice, the flow resource below the control point has lost its significance. Instead, the exposed riverbed is used as a renewable fund resource. Two cross sections have been selected for display from the moribund Amta channel (Fig. 6.36).

Section-1 shows cultivated lands between the base of the left bank embankment and the thalweg. The area between the right bank embankment and thalweg is cultivated. The land adjacent to the thalweg is divided into several plots by earthern dykes. Water is collected in the area enclosed by dykes and wet rice is cultivated. A prawn-fish project was proposed but the proposal was dropped due to protests from environmentalists. Vegetables are grown together with paddy. The area below the right embankment is used for homesteads.

Section-2 shows similar features of land use. The only difference is that there are betel leaf plantations near the left bank embankment and tile factories near the

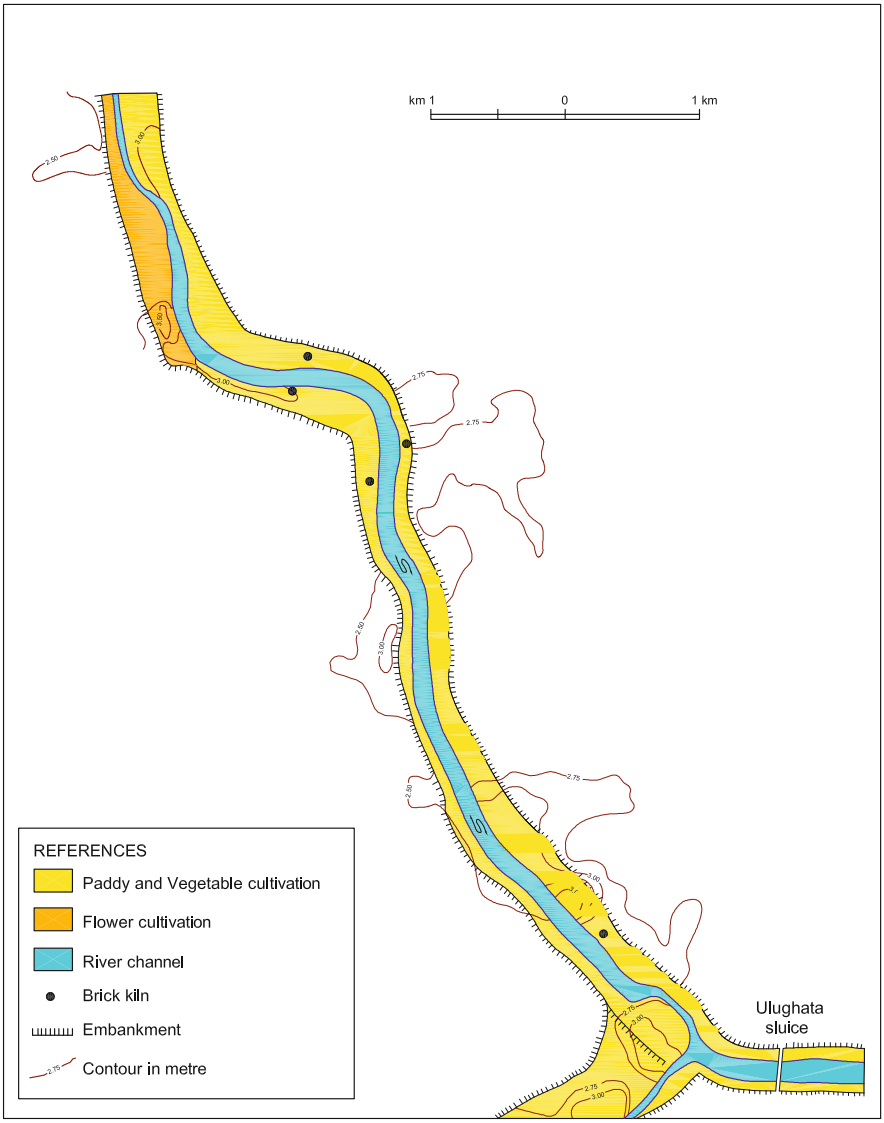

Fig. 6.35 Generalized land use characteristics of a part of Amta channel
Map prepared from 1: 15,000 79 B/13/2 and through active field survey

right bank embankment. The ditch just below the right embankment now contains a *hogla* jungle (a kind of tall grass). It is noteworthy that the betel leaf plantations are sited on the higher part of the riverbed, as are the tile factories (Bhattacharyya 1998).

The marginal bars mentioned so far are not settled in general. A few hamlets are to be found on the right side. The biggest settlement is the Bahir Aima (Fig. 2.6).

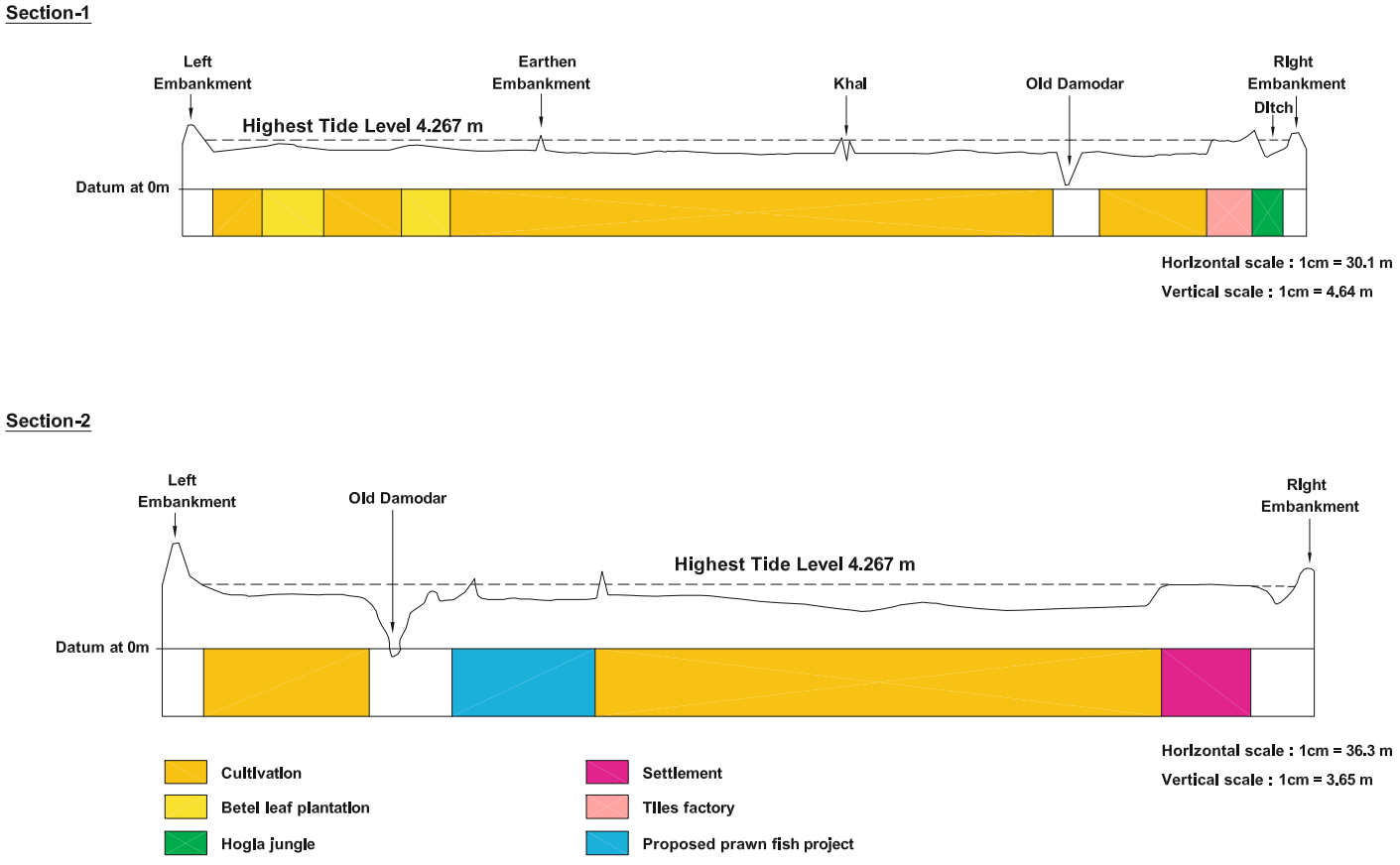

Fig. 6.36 Cross sections showing interrelationship between physical and cultural landscape at defunct section of the Amta channel This Figure prepared from cross sections collected from I & WD, WB and through active field survey

6.11.1 Bahir Aima

Bahir Aima is the farthest settlement on the Lower Damodar from the Panchet and Maithon reservoir. The distance between Gangtikuli, the first settled bar just below the Maithon and Panchet reservoirs, and Bahir Aima at the Falta outfall, is approximately 250 km. This settlement is an extension of the Alipur settlement. Bahir means outside and Aima denotes settlement. Bahir Aima is sited on a marginal bar in the Hooghly estuary. It comes under the mouza Alipur under the Srirampur police station of the Howrah district. It is sited at a previous confluence point of the Damodar with the Hooghly. The nearest railway station is Bagnan.

Bar formation in any estuary is a part of an estuarine process. Due to the mixing of salt water with freshwater, flocculation takes place and there is rapid sedimentation leading to bar formation. The Bahir Aima bar was probably a product of this process at the initial stage. We noted earlier that the Amta channel started deteriorating after 1865. The construction of the Durgapur barrage and the Panchet and Maithon reservoirs has further reduced the amount of stream discharge since 1958 and finally, due to the construction of the Ulughata sluice, the lowermost part of the Lower Damodar has deteriorated further. As a consequence, a sluggish environment was created at the Falta outfall that was conducive to the formation and enlargement of bars. The construction of embankments in 1956 led to vertical and lateral accretion, thus enlarging the Bahir Aima bar. Near Bahir Aima, the Amta channel is so narrow that it looks like a village nala (Plate 6.16) but ruined dilapidated bacon still bears the evidence of the past glory of the Falta outfall.

The Bahir Aima is dominated by Muslims who migrated to this bar after 1958. There is a floating population from Alipur. They have land in Bahir Aima but are not settled there. Settlements are on the landward side of the bar. Cultivated fields extend right up to the riverfront. In fact, the riverfront is preferred due to fortnightly replenishment of soil fertility by tides in an otherwise moribund situation. In the British period, salt used to be manufactured from saline water intrusion but now this activity is not significant. Wet rice and vegetables are grown here but there is a lack of crop diversity in general. The bar is so stable that coconut and palmyra trees have been planted everywhere (Bhattacharyya 1998).

6.12 Summary of Land Use in the Amta Channel

The thalweg of the Amta is extremely narrow compared with the culturally defined riverbed. Embankments have been constructed at equal distances from the natural river. The right bank embankment is comparatively closer to the river whereas the left bank embankment has been constructed quite a distance away from the main river at many places. The embankments are rather evenly spaced in the lower part of this section. Configuration of the culturally defined riverbed varies between almost level surfaces to slightly undulating surfaces. Riverbed occupiers are mostly local residents. Among locals, Hindus dominate, though there are a few Muslim families.

Almost the entire bed is used for cultivation. Crops vary from paddy to potato. Transverse dykes have been constructed on the riverbed for paddy culture resembling basin irrigation of ancient Egypt. There is an extensive floriculture in some of the inundation-free marginal bars. Proximity to the Jagannath ghat flower market and connectivity to this market by roads and railways have encouraged floriculture, a striking land use characteristic of the controlled riverbed of the Amta channel. Economic factors have helped in creating betel leaf plantations on higher parts of the riverbed. Tile factories and brick kilns are observed on the highest part of the inundation-free riverbed. Hogla forests are found in marshy areas of the riverbed. A proposal for prawn culture was dropped due to protests from environmentalists. The natural levee is almost lined up with the settlements in a few places. Embankments are used as village roads.

The flow resource is losing its significance, particularly below the Ulughata sluice, but marginal sandbars are extensively used. The emphasis on perishable but expensive crops like flowers and betel leaves is noteworthy. This risk has been taken because of market facilities available in nearby Howrah and Calcutta and due to easy market access by road and railway. Urban markets in the vicinity have also made tile factories and brick kilns significant components of the cultural landscape. These components are not so significant in other two sectors of the Lower Damodar (Bhattacharyya 1998).

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