Chapter V
IMPACT OF LATERAL CONTROL STRUCTURES

5.1 INTRODUCTION
Culturally defined Lower Damodar with multitudes of control structures now demands reasoned and exemplified answers of the following questions:

i. What are the hydro-geomorphological consequences of control structures?

ii. What is the socio-economic relevance of such control measures on the adjacent riparian tract and on the river bed itself?

When local landlords decided to construct embankments, their decisions were influenced by immediate gain i.e., to protect riparian tract from flood hazards. Side effects of such measures and wider physical consequences were never thought of. The E.I.A. movement was a far cry when the T.V.A. was conceptualized in 1933 and when D.V.C followed the U.S.A. model in 1948. Series of reservoirs and barrages have come up as a consequence of planning decisions taken by the engineers, planners and politicians to tame the Damodar but no attempt has been taken yet either by the D.V.C. itself or by any other non-government agency to analyse the physical consequences of such control measures in a systematic manner. It is admitted, that for such impact analysis not only an inter-disciplinary approach is desirable but also team work is a necessary pre-requisite. Therefore, it is impossible for a single researcher to handle such crucial questions.

Nevertheless, an attempt has been made to focus on these questions from applied geomorphological view points. For convenience of discussion, these issues have been addressed in two separate chapters. The chapter five discusses the impacts of lateral control structures and the chapter six examines the impact of transverse control structures though it is acknowledged that the impacts of embankments cannot be severed from those of reservoirs. Addressing of issues of similar nature in two separate chapters will be clarified when methodological problems for the present chapter are discussed.

In the previous chapter control measures in the Lower Damodar were treated as effect and flood was considered as a cause. In this chapter and in the following chapter control measures are treated as causes behind consequent hydro-geomorphic changes in the riverbed and in the adjacent riparian tract or in other words the very status of control structure has changed from ‘effects’ to ‘causes’.

5.2 OBJECTIVES
Objectives of the present chapter are to examine:

i. the impact of embankments on the river bed.

ii. the changes in soil composition in the adjacent riparian tract.

iii. the consequences of the removal of the right bank embankment on river bed and spill channels.
CROSS SECTIONS OF DAMODAR AT SELECTED SITES

(1) RAGHABPUR

H.F.L in 1913 (38.7 m)

Bed in 1888

Bed in 1943

Distance in metres

Horizontal Scale: 1cm = 120 m
Vertical Scale: 1cm = 1m

(2) JUJUTI

H.F.L in 1913 (38.3 m)

Bed in 1888

Bed in 1943

Distance in metres

Horizontal Scale: 1cm = 90 m
Vertical Scale: 1cm = 3m

Source: I & WD, W.B.

Fig. 5.1
iv. the impact of the left bank embankment on silt recharge and drainage conditions.

v. the changes in regional slope due to removal of embankments.

5.3 METHODOLOGICAL ISSUES

In river training programmes, quantified data on hydro-geomorphological parameters of the river are of paramount importance but socio-economic demands of the community are prioritized in planning programmes. Similar to examine in the hydro-geomorphological consequences of control measures a set of quantified data is required which helps researcher to take a much desirable nomothetic method. In case of the river under consideration, the Lower Damodar, quantified data neither on the embankments nor on the discharge and sediments are available. Mostly qualified archival data have been used. So, the nomothetic method has not been selected for reviewing the impacts of embankments on selected hydro-geomorphological conditions. In the next chapter where the impacts of transverse control structures have been examined and quantified data are available a nomothetic method has been selected. Because of this particular methodological problem the impacts of transverse control structures has been treated in a separate chapter.

Following King (1966) it may be said that method of analysis is inductive. It is most probably justifiable if it can be stated that a historical method has been applied as the data base is historical data base.

During floods like any other river, Damodar used to cross its normal boundary in pre-embankment days. Part of the valley is still inundated in its unconfined sector and when embankments are breached or over-topped the river is extended. This extension of the river during floods needs to be considered while dealing with spatial scale of inquiry.

For impact analysis of the embankments the total time span is 145 years i.e., from 1852 to 1997.

It is already mentioned above that the data base is mostly historical. Qualified data from old maps, Government reports and records etc. have been generated. With these passive data, active field data from 1990 onwards have been used.

Techniques adopted are interpretation of historical data in geomorphological terms and field survey technique. Old maps, the basic tools have been consulted.

5.4 SEQUENCE OF DISCUSSION

The controlled river bed is considered first. Secondly, fertility status of the adjacent riparian tract is reviewed. The consequences of the removal of the right bank embankment have been focused on. Finally, the discussion is centered on the impact of the left bank embankment.

5.5 IMPACTS OF EMBANKMENTS

An embankment is a cultural feature which becomes a viable component of a historically conditioned geomorphic landscape. How an embankment disrupts the physical process is
"HANAS INSIDE THE DAMODAR ELBOW

After Bose 1948

Fig. 5.2
discussed below. In the course of discussion the area outside the embankments has also been ventured on to strengthen some of the arguments.

5.5.1 Rising River-Bed

Like any other embankment, the Lower Damodar embankments have interfered with the physical process of sediment transfer and deposition. The Damodar bed load is rich in sands as it flows through a quartz rich gneissic terrain in its upstream sector and sandstone rich Gondwana sedimentaries in the lower reach of the upstream sector. “It is very hard to measure the bed load, or even to estimate it very closely” (Morisawa, 1968:46). But from the bed load characteristics it can be inferred that in the pre-embankment days the river became a wide shallow river with braided channels. As the river was extremely floodable, a sizable portions of the bed load used to be deposited in the immediate flood plain during floods. In the post-embankment phase flood discharge of the wide and braided Damodar is unable to spill and deposition takes place on the river bed itself. The most probable consequence, therefore, is the gradual rising of the river bed. Guliemini’s (an Italian Engineer) statement cited in the report of Goodwyn (1854) that the river is depended due to restriction but where the bed is wide and divided into branches, it’s bottom will be raised, which can be applied for the Damodar. The river cannot be kept in a state of regime, neither can it be deepened owing to the sandy and unstable nature of it’s bed (Bannerjee, 1943). The 1854 map of Dickens show Damodar with a large number of sand bars. R.A. Marston and others have similar observations on the Ain river, France, where embankments prevent lateral reworking of flood-plain alluvium and sediments are stored within channel (Marston et al., 1995).

5.5.2 Changes in Soil Composition in the Adjacent Riparian Tracts

In the report of the Embankment Committee 1846, there are some remarks on the produce of the land outside and inside of embankments. Landlords had a feeling that land protected by embankments were deprived of the fertilizing effects of the Damodar floods where as in the unprotected tract, in addition to the usual varieties of rice, mulberry, sugarcane, brinjal, Bengal hemp (Crotolaria-juncca), chorchorh-capsularis (cultivated for its fibre), Eeschynomine connbina etc., could be raised. About 32.2 kms below Barddhaman, rice was the only crop within embankments where as outside the embankment Arum, Crotolaria juncca cotton could be cultivated (Sage et al., 1846). Embankments provide full protection upto a certain stage and they may be breached or over topped or collapse due to piping action near the toe of embankment (Ward, 1978). In the historical past long before the construction of reservoirs the Lower Damodar breached its embankments in 1770, 1787, 1789, 1823, 1835, 1840, 1845. Atleast 25 breaches occurred in 1847, 14 in 1849, 56 in 1850, 45 in 1852 and 28 in 1854 (O’Mally and Chakravarty, 1912). Though these breaches are used to be interpreted as natural consequences of unusual floods but it was not unlikely that these were secret breaches made by the villagers for irrigation purposes. The common people used to believe that had there been no embankments, river water would have had free ingress in the rice land and the adjacent riparian tract would have benefitted from deposits of the Damodar silt (Sage et al., 1846).
From the above discussion one has to conclude that soil composition in the tract protected by embankments changed due to entrainment of sediments in the river bed and lack of annual replenishment in the adjacent tract. Additional deposits of sediments on the river bed ultimately become socio-economically significant and this will be discussed in chapter eight.

5.6 CONSEQUENCES OF THE REMOVAL OF THE RIGHT BANK EMBANKMENT

In the previous chapter, it has been discussed under what circumstances decision to remove a part of the right bank embankment was taken. Now situations in the pre-removal and post-removal of embankments will be compared.

5.6.1 Changes in Fertility Status on the Right Bank

Prior to the removal of the right bank embankment it was reported that 762 villages with a total of 619.13 sq.km. would be liable to floods if the embankments were removed. Of these 64.95 sq.km. were unculturable lands. But approximately 35.30 sq.km. uncultivated land would be benefited by floodborne sediments and 222.71 sq.km. of cultivable lands would be injured, so, as a whole only 40 per cent would be rendered more or less unfit for cultivation (Young 1861).

Removal of these right bank embankments initially created problems to adjacent villages. Loss due to periodic inundation of an appreciable amount of paddy lands, was assessed as Rs. 5 million (US $ 135135, £8928). This was calculated on the basis of price behaviour prevailing in 1951 (D.V.C. 1995). But the only consolation for such periodic floods was the deposition of silt which enriched agricultural lands, facilitating production of splendid crops of rabi (winter crops, harvested in spring) and thus compensated for the loss of summer paddy crops (Sengupta, 1955). So, ultimately cultivators were benefited by the removal of the right banks.

5.6.2 Changing Cross Profile

The right bank embankments was demolished in 1859. The D.V.C. report of 1957 vol. II, states that the arrangement gave relief for a certain number of years. By throwing away the embankment on the right side the cross section of the flow must have been enormously increased and there was corresponding lowering of the level of high flow. But at the same time the velocity of the flow was considerably reduced and thereby increasing the rate of silt deposit in the bed and resulting in the raising of its level more rapidly than before. On this issue there were some controversies also (D.V.C., 1957, Vol. II).

5.6.3 An Increase in Cross Section

The cross section of the channel at different points increased enormously between 1881–1943 (Fig.-5.1) and there was corresponding lowering of the level of high flow. In some places the cross sections are characterised by pronounced flood plains between embankments or between embankment and river levees. When these get inundated, velocities on the flood plains is lower than those in the thalweg itself. This causes the effective cross sectional area in the river to become smaller than the actual geometrical
CROSS PROFILES OF DAMODAR AT SELECTED SITES

GOHAGRAM (23°15'30"N, 87°37'40"E)

IDILPUR (23°13'30"N, 87°49'50"E)

PALLA (23°10'N, 87°54'50"E)

Fig. 5.4
cross section (Report, 1983). The width of the river has been increased over the years (Table 5.1).

**Width of the Damodar River at different places between 1881-1943**

<table>
<thead>
<tr>
<th>Stations</th>
<th>1888</th>
<th>1913</th>
<th>1918</th>
<th>1943</th>
</tr>
</thead>
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<tr>
<td>Raghabpore</td>
<td>1097.28</td>
<td>2072.64</td>
<td>2072.64</td>
<td>1928.336</td>
</tr>
<tr>
<td>Jujuty</td>
<td>987.552</td>
<td>1298.448</td>
<td>1310.64</td>
<td>1524</td>
</tr>
<tr>
<td>Edilpur</td>
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<td>1245.41</td>
<td>1245.41</td>
<td>1127.76</td>
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<tr>
<td>Becherhat</td>
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<td>1164.92</td>
<td>1280.16</td>
<td>1173.48</td>
</tr>
<tr>
<td>Manikhati</td>
<td>853.44</td>
<td>853.44</td>
<td>835.15</td>
<td>1066.8</td>
</tr>
<tr>
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<td>897.65</td>
<td>893.07</td>
</tr>
<tr>
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<td>384.05</td>
<td>396.24</td>
<td>365.76</td>
</tr>
</tbody>
</table>

Source: Sen S. K. 1962

5.6.4 Opening Up of Hana or Spill Channels on the Right Bank

A chain of ‘Hanas’ or ‘Spill Channels’ opened up by breaching natural levees on the right bank. These breaches or spill channels are locally known as ‘Hanas’. A chain of spill channels serves as a spill ways for flood waters of the Lower Damodar to overflow into the low land through which runs the Debkhal and its ramifications. Entire lowlying area becomes a sheet of yellow water moving eastward and then south wards during rainy season. Thus the flood water unable to pass through the restricted channel of the main river find its way into the Debkhal and its ramifications. Entire lowlying area becomes a sheet of yellow water moving eastward and then south wards during rainy season. Thus the flood water unable to pass through the restricted channel of the main river find its way into the Debkhal (Bose, 1948, Fig.-5.2). In 1956 maximum discharge at Rhondia (at 24 hours) on the 26th September was 8694 cumec, maximum discharge at Jamalpur on the 27th September was 3002 cumec, maximum discharge at the Muchi hana on that day was 7307 cumec and at Champadanga was 708 cumec on that very day. So, it appears that a discharge of about 5692 cumec passed over the right bank in the reach between Silna and Jamalpur (D.V.C., 1978). Due to such spilling over the right bank, the left bank embankments were not breached during major floods of 1959 and 1978.

This spilling over the right bank has decreased now as the river has formed a natural levee and most of the spill channels on the right bank are either closed or take lesser amount of water and leave sediments to be deposited within the channel itself. As a consequence, the river bed and the flood level have risen considerably. Previously the Damodar used to open up flood channels towards north east or south east. While discussing the changing courses of the Lower Damodar, it has been mentioned how a flood channel become the main channel. As the left bank is protected by embankment, spill channels in the historical past have opened up on the right side.
SHIFTING OF LEFT BANK OF DAMODAR
NEAR SRIRAMPUR (22°11'30"N, 87°53'E)

H.F.L = 32.5 m (P.W.D.)

Datum at 12 m

Distance in metres

Horizontal Scale: 1 cm = 6 m
Vertical Scale: 1 cm = 2.5 m

Fig. 5.5
5.6.4.1 Origin of the Begua and the Muchi hana and deterioration of the Amta Channel

A natural flood channel known as Begua hana was probably opened up in 1865. The river below Surekalna had already formed an acute bend, which was affecting the left bank embankments. By 1856, a well defined spill channel had formed on the right bank of the Damodar to relieve the pressure on the left bank embankments. In an old map as has been mentioned in the D.V.C. report of 1957 it appears that in 1857 a dyke was put up across the Damodar below this spill channel which had probably helped in the development of the Begua hana. Later on a cut-off known as the Muchi-hana was effected by joining the neck of the loop formed by the Begua hana at Muidipur under the Jamalpur police station. Locals believe that this artificial measure was taken to protect the settlements and the railway line on the left bank. Floods below the Muchi spill channel are now attributed to this artificially cut spill channel (Ghosh, 1993, Fig.-5.3). Bird (1980) observes similar phenomenon in the Lang Lang river, Victoria, Australia where an artificial neck cut-off has made for straightening the channel.

Around 1865, a great Begua breach occurred and scoured out a channel parallel to the main Damodar known as the Kanki that eventually joins the Mundeswari river (D.V.C., 1957, Fig. 5.3). The combined stream falls into the Rupnarayan river. At this bifurcation point, formation of a high sand bank completely shuts off the flow of water into the Damodar, known as the Amta channel below this bifurcation point. And newly scoured bed of the Muchi-hana is lower than the sand filled bed of the main Damodar (Bose, 1948, D.V.C., 1957), which is now used as cultivated fields in non-monsoon period.

The Amta channel i.e., the lower most part of the Lower Damodar gets water through the Begua hana and this channel, due to reduced discharge has shrunk perceptively in size and volume as the downstream discharge in the lower reaches below bifurcation point into the Kanki-Mundeswari and the Amta channel share eighty per cent and twenty per cent respectively (D.V.C., 1995). Unfortunately the amount of discharge has not been mentioned. The Kanki-Mundeswari channel hydrologically formed a much shorter route than the Amta channel route via Uluberia. Under these circumstances the old Damodar i.e., the Amta channel gradually deteriorated not only because of its longer hydraulic length but also because of its absence of spill area as this channel at present is embanked in both side excepting in few places on the right side and also due to gradual encroachment on the river bed (D.V.C., 1995). Bankfull capacity of the Mundeswari is hardly 2265 cumec and the Amta channel can carry only 566.4 cumec. The channel has silted up so much that hardly 5 to 10 per cent of the discharge passes through it (Sen, 1991).

5.7 IMPACT OF THE LEFT BANK EMBANKMENT

To save the town of Barddhaman, the G.T. Road and the railway line from flood havocs, the left bank embankment was not only strengthened but disjointed portions were jointed and in places a second line of embankments was constructed. The consequences often became hazardous. Secondly, changes have been observed in the regional slope also.

5.7.1 Drainage Congestion

The district of Barddhaman is bounded by the Ajay to the north and the Damodar to the south. The watershed is ill-defined particularly in the east. The Khari and Banka drain this area. Previously much of the Damodar flood water used to pass through these two
SHIFTING OF BANKLINE
HATSIMUL MOUZA TO KANTHALGACHI MOUZA

Proposed protective work
Existing protective work
Proposed protective work

DAMODAR R.

Unauthorised Agriculture

Source: I & WD, W.B.

Fig. 5.6
rivers, but roads, railways and embankments have severed these rivers from the mother stream. As a natural consequence both the rivers have deteriorated and have become flood-prone. Secondly, the water that used to flow into the Damodar now creates water-logging conditions in this low inter-stream area. This drainage congestion has been reported by Haig (1873) and by Biswas and Bardhan (1975). Water logged condition is conducive for breeding of mosquitoes and the region for decades has suffered most from Barddhaman fever, a kind of malaria. Water logged conditions affected agriculture and the region had to face fever, famine and depopulation in between 1850 and 1925 (Biswas and Bardhan, 1975). Though drainage conditions have improved in recent years but a few pockets still suffer from drainage congestion and its consequences. The area discussed above falls outside the study area but occasional trespassing becomes necessary to fortify some of the arguments against the unplanned chaining of the river.

5.7.2 Reversal of Slope

Previously the regional slope was from Barddhaman side towards Bankura i.e., from north to south. Southern bank is not protected. Therefore, there is continuous siltation in flood plain of the south bank or right bank. As a consequence, right bank flood plain has become higher and it forces the thalweg to move northward creating pressure on the left bank embankment. This reverse slope (Fig.-5.4) is a noticeable consequence of the removal of embankments on the right and presence of embankment on the left. In 1995 floods, some of the abandoned flood channels on the left have been re-activated and the left bank embankment has breached in several places. The left bank is thus becoming vulnerable. Figure 5.5, 5.6, 5.7 show how bank line has shifted between Shrirampur and Kalinagar near Palla village. Migration of banklines and consequent problems in the Brahmaputra in Bangladesh have been noted by Goswami (1988), Thorne (1993). The shifting trend of the Kosi has been studied by Ansari (1987).

5.8 SUMMARY

Flood prone Lower Damodar was chained with a series of embankments to protect adjacent riparian tract from flood hazards. To meet public demands part of the right bank embankment was demolished. Following are the consequences in a nutshell:

i. Gradual rise of the river bed.
ii. Changes in soil characteristics in the adjacent riparian tract due to non-renewal of flood-borne silt.
iii. Soil characteristics changed on the right bank due to removal of the right bank embankment.
iv. Widening of the river between embankments.
v. Rise in the river bed due to removal of the embankment.
vi. Opening of spill channels on the unprotected right bank.
vii. Opening of the Begua and the Muchi spill channels on the right.
viii. Drainage diversion through the Kanki-Mundeswari.
ix. Deterioration of the Amta channel.
x. Drainage congestion to the north of the left bank embankment.
xi. Incidence of Barddhaman fever increased due to drainage congestion.
xii. Shifting of thalweg towards Barddhaman side due to reversal of slope.
xiii. Shifting of bank lines on the left bank.
SHIFTING OF BANKLINE
MANIKHATI MOUZA TO KALINAGAR MOUZA

- Manikhati Mouza
- Jafrabad Mouza
- Kalinagar Mouza

Fatehpur Village

DAMODAR R.

Sand Bar

Sand Quarry

Bankline 1985
Bankline 1984
Bankline 1979

Unauthorised Agriculture during non-monsoon period

Source: I&W D, W.B.

Fig. 5.7