RIVERS AND FLOODS
(With Special Reference to Floods in West Bengal)

Supriya Sengupta*

FLOODS occur in rivers. Before we can understand why rivers flood we must know what rivers are and how do they behave.

Rivers originate out of the natural hydrological cycle. Clouds generated by evaporation of water in the sea are drawn into the land. These clouds cause precipitation in the form of snow at high altitude and as rain at lower altitude. A large proportion of the precipitation that takes place on land finds its way back into the atmosphere through evaporation and transpiration. The rest flows into the sea mostly as surface run off through streams. A small part of water also percolates into the ground and flows to the sea as ground water. This, of course, is a very general picture. The actual amount of surface run-off responsible for movement of water in streams varies from place to place depending on various factors — local, regional, and global. However, the net amount of water involved in this cycle has not changed ever since the earth, with its solid, liquid and gaseous parts, came into existence more than 4000 million years ago. Needless to mention that terrestrial life would not have been possible without this hydrological cycle.

Two types of rivers originate out of this hydrological process:

1. the *perennial* rivers which are snow fed, and
2. the *ephemeral* rivers which are dependent wholly on rainfall in the catchment area.

*Formerly Professor of Geology at the Indian Institute of Technology, Kharagpur.

The Ganga and the Brahmaputra are good examples of perennial rivers. The Damodar and Ajay are examples of ephemeral rivers.

The pattern of drainage network, which develops out of the foregoing process, is schematically represented in fig.1. The bigger loop in this diagram is called the contributing (C) net. Many tributaries, big and small, contribute to the water discharge of the principal river within this net. The smaller loop is the distributing (D) net. Dis-

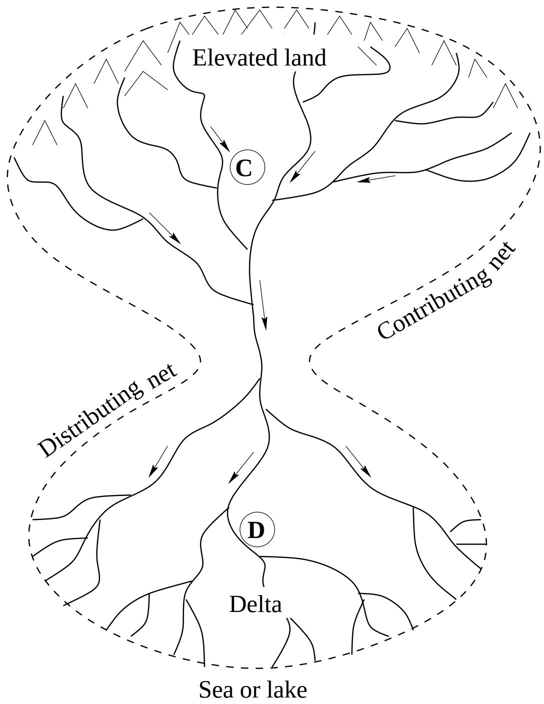

Figure 1: Drainage network of a typical river system.

tributary channels flowing out of the principal stream within this loop carry water into the ocean or large lakes. While doing so, they often cut through the silt laid down by the stream leaving triangular or delta shaped bodies.

The flow of water within a stream channel is not a very simple one. Laboratory experiments have shown that whenever the velocity of water exceeds a certain limit, the channel describes a sinuous pattern. This causes complications because centrifugal forces generated at the meander bends impinge on the inner concave bend of the channel causing erosion. The water surface at this bend also bulges up. A helical flow develops due to superimposition of the centrifugal flow on the normal downstream motion of water within the river channel. The eroded materials, caught in this helical flow, are put into a circular motion. These materials eventually come to rest on the opposite bank of the river channel where they accumulate in the form of sandbars, called *point bars* (fig.2).

Figure 3 is a profile of a stream channel across a meander bend. The channel is V-shaped in its youthful stage but gradually becomes U-shaped with maturity. The flow of water within the V-shaped channel may be represented by a simple equation:

$$Q = A.v,$$

where
Q = water discharge within the channel,
A = cross-sectional area of the channel, and
v = velocity of the water flow.
The cross-section of the V-shaped channel being smaller at the bottom the flow here is capable of transporting large grains of sediment like pebbles, or even boulders. The flow velocity gradually decreases upwards. Finer sediments like sand and silt, whose fall velocities are balanced by the vertical component of turbulence in the stream channel, are carried in suspension in the upper part of the channel.

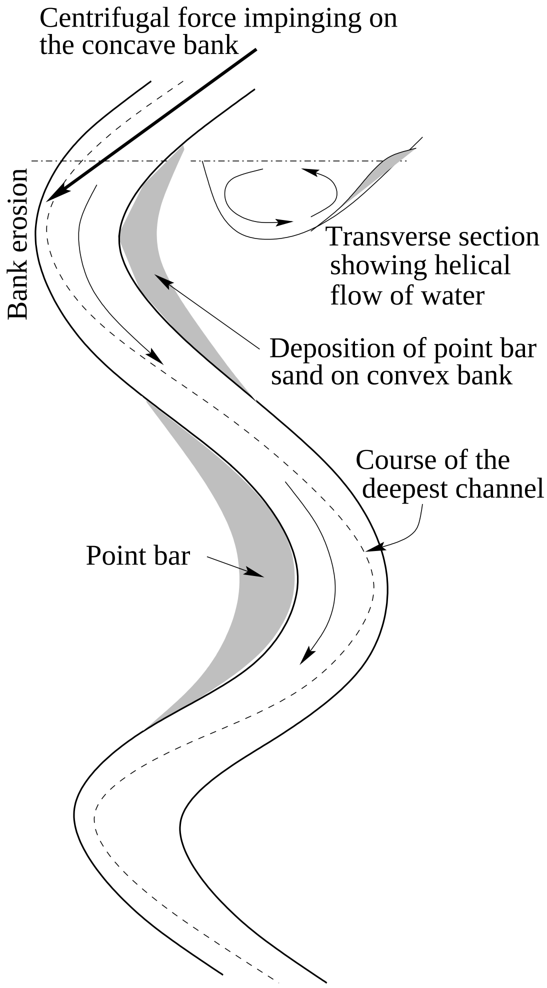

Figure 2: Mechanics of water flow in a meandering channel.

Having defined the basic mechanism of flow in a river, we are now in a position to discuss floods. Flooding involves spilling over of water in motion in the stream channel. Periodic spilling is not only normal for a stream but it is also a very welcome process. A river in flood distributes a large part of its suspended sediment load into the adjacent flood plains, thereby enhancing its

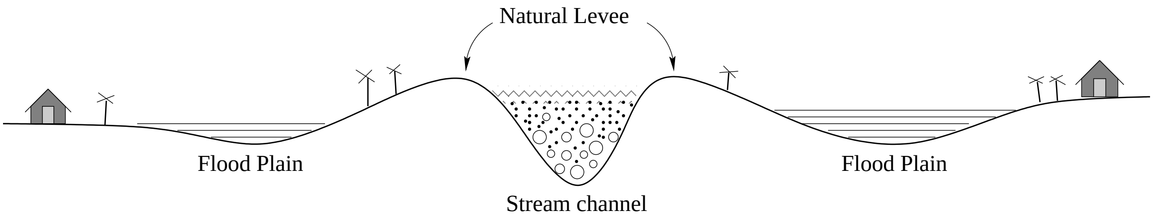

Figure 3: Transverse profile of a typical river.

fertility. A part of the sediment load also settles down on the banks of the river building up embankments called *natural levees.*

Whether the water in motion within a channel will spill depends partly on the amount of water available, and partly on the capacity of the channel to hold this volume of water. A glance at fig. 1 tells us that the distributaries of a river system will flood whenever the water contributed by the tributaries does not find easy passage into the sea. In other words, the larger the ratio of C/D, the greater is the chance of flooding. A river will also flood when excessive siltation within the channel decreases its effective capacity to hold water. Normally, as a stream channel attains maturity, a balance is reached between various parameters like water discharge, channel cross-section, sediment load and the like. At this stage, If the natural embankment is further raised artificially, with a view to controlling floods, more silt is deposited within the channel thereby reducing its effective cross-sectional area. At this stage the propensity of flooding increases and the very purpose of constructing an artificial embankment is defeated. This has happened in many rivers during recorded history.

The Rivers of West Bengal

With the information gathered on the basic mechanism of a stream flow we are now in a position to discuss specific problems concerning the rivers of West Bengal. Only one perennial river, the Ganga, runs through the central part of this state (see Fig. 4). The same river, flowing through Bangladesh, is called the Padma. Within West Bengal, several distributary streams, of which the Bhagirathi-Hooghly is the most important, carry the water of the Ganga into the sea. Several tributaries, Pagla, Bansloi, Brahmani, Dwarka, Maurakshi, and Ajoy join the Bhagirathi from the west.

The Damodar used to flow directly into the Bhagirathi-Hooghly channel in the past. At present, it flows into the tidal basin of the Rupnarayan. Other rivers joining the tidal basin are the Dwarkeswar, Silabati (Silai) and Kangsabati (Kasai).

Of the north Bengal rivers the two most important ones are the Mahananda and the Tista. The Mahananda, a rain-fed river, drains almost the whole of north Bengal, before joining the Ganga. The Tista, fed by the Himalayan glaciers, enters Bangladesh beyond Jalpaiguri to join the Brahmaputra.

The drainage problems of the Bhagirathi-Hooghly distributory system and the Damodar-Rupnarayan ephemeral streams are discussed below under two separate heads. These discussions broadly apply to all other rivers of southern West Bengal. The rivers of north Bengal, which emerge from the Himalayas and flow either into the Ganga or the Brahmaputra, are beyond the scope of the present discussion.

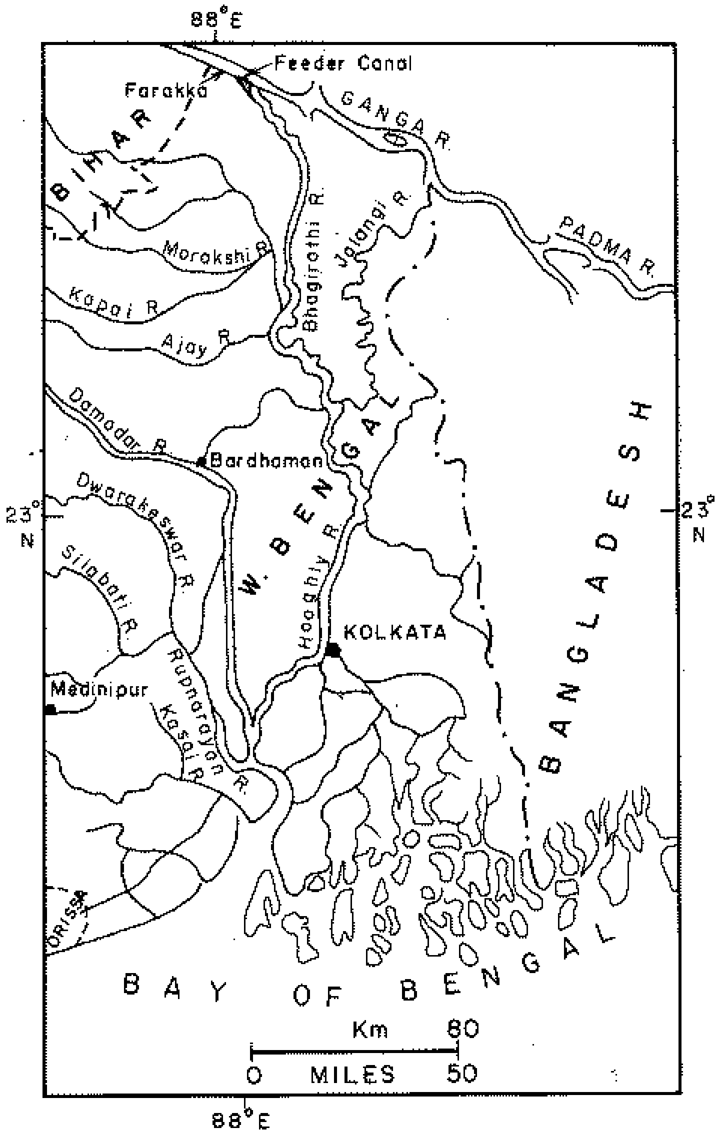

Figure 4: The major river systems in southern West Bengal.

The Problems of the Bhagirathi-Hooghly

The take-off point of the Bhagirathi from the Ganga oscillates between Rajmahal and Lalgolaghat, a distance of approximately 60 km. The Bhagirathi flows in a southerly direction for a distance of about 560 km before debouching into the sea. The southern part of the river, which is under tidal influence, is called the Hooghly.

Two factors are responsible for frequent flooding of the Bhagirathi and its associated stream channels. Firstly, the catchment area of the Ganga, lying within the territories of India and Nepal, is exceptionally large (about a million square kilometers). All the major distributaries of this large catchment, however, lie within the Bengal delta, which is not more than 59,000 square kilometers in area. This large C/D ratio is a major factor responsible for flooding of the rivers within the Bengal delta. Another problem responsible for flooding is excessive siltation within the distributary channels. The average suspended silt content in the Bhagirathi is about 0.42 gm/litre. During rainy seasons, it may go up to about 1.70 gm/litre in places. To add to the problem a large part of the silt accumulated at the mouth of the Bengal estuary is driven into the Hooghly channel by tidal current. The flow velocity during the ebb being less than that of the tide, a large part of this silt settles down within the Hooghly channel thereby reducing its effective cross-section. Excessive siltation of the Hooghly channel has, in fact, been a serious problem for navigators for a long time.

Although the Ganga has a perennial source, the Bhagirathi receives an adequate supply of water only during August-September when the flow in the Ganga exceeds a million cusecs. During dry months, this flow hardly exceeds 70,000 cusecs. Only a small part of this water finds its way to the Bhagirathi channel because excessive siltation keeps the Bhagirathi channel disconnected from the Ganga during a large part of the year. The flow in the Bhagirathi during the lean period is dependent mainly on the effluent seepage that percolates underground. Tributaries like the Maurakshi, Ajay, and Kopai also contribute, to a limited extent, to the flow of the Bhagirathi. Themselves being ephemeral, these streams have very little water in their channels during the dry season. Moreover, following construction of the retention dams on the Damodar and the Barakar rivers (discussed in detail in a separate section below) the flow into the tidal basin of the Rupnarayan, which ultimately emerges into the Hooghly estuary, has decreased considerably. On the other hand, periodic floods in the tributaries of Bhagirathi can also prove to be disastrous. According to Dr. N. K. Bose "as the Ajoy flood come down the river channel like bores, due to the steep slope of the river bed, disturbances are produced in the flow of the Bhagirathi that travel down the hooghly and cause extensive sand movements in the bars and crossings of the navigable sea route from Calcutta."

Excessive siltation has caused the Bhagirathi channel to migrate laterally on many occasions during the recorded history. Innumerable terraces, cut-off channels and oxbow lakes bear testimony to this lateral migration over the years. Needless to mention that settlements bordering the Bhagirathi suffered enormously during lateral migration of the river channel. Erosion of the inner concave bank is one of the perpetual problems associated with river channels. Villages located on this bank have disappeared while new bars appeared on the opposite banks.

Although erosion of the inner concave bank can hardly be tackled, the silt accumulated in the river channel can be removed in two ways — namely, dredging and flushing. From the early part of the twentieth century, the Hooghly channel near the estuary is being kept navigable by the Port Commissioners of Calcutta by dredging. This, however, provides only a temporary remedy because the silt excavated and dumped nearby soon finds its way into the channel during next monsoon. It is mainly for this reason that an alternative berthing facility for ocean liners had to be made at Haldia, located nearly 100 km southwest of Calcutta.

As far as the flushing technique is concerned, theoretical calculations as well as experimental studies have shown that a minimum flow of 40,000 cusecs round the year would keep the Bhagirathi channel clean of silt. To make this water available a canal connecting the Ganga and the Bhagirathi was dug in 1975 near Farakka. A reservoir was also constructed near the main channel of the Ganga to provide water into the Bhagirathi. This construction, unfortunately, created problems of both national and international dimensions. At the time of construction of the feeder canal, it was assumed that the Ganga would have a supply of at least 70,000 cusecs round the year. Withdrawal of excessive amount of water by the states of Uttar Pradesh and Bihar in recent years, however, has reduced this supply considerably. It has been argued that following the withdrawal of a further amount of 40,000 cusecs at Farakka, Bangaladesh will not get an adequate share of water during the lean season. Several committees met during the last few decades to discuss this issue but hardly any workable solution has been arrived at. A few years back the Prime Minister of Bangladesh and the Chief Minister of West Bengal settled upon a variable amount of flow into the Bhagirathi depending on the amount of water available in the Ganga. Unfortunately, this agreement also does not assure a steady supply of 40,000 cusecs in the Bhagirathi channel round the year.

The Problems of the Damodar Valley

The Damodar valley occupies an area of about 24,000 square kilometers within the states of Bihar and West Bengal. High rate of soil erosion at the source areas contributes large amount of silt to the streams belonging to the Damodar river system. A sudden drop in the gradient of the river as it enters West Bengal, causes most of this silt to settle near the border of Bihar and West Bengal. Annual rainfall within the catchment area of the Damodar is about 120 mm on the average. This rainfall being restricted almost wholly to the monsoon months (June to October), the channel of the Damodar can hardly hold the sudden influx of water. Thus, this river valley experienced disastrous floods in the past, notably during 1913, 1927, 1935, and 1943. Following the last mentioned flood, a committee was set up by the government to investigate into the reasons for frequent flooding of the Damodar valley and to suggest remedial measures. The committee, which included scientists like Prof. M. N. Saha and Dr. N. K. Bose, proposed a comprehensive plan for flood control and river valley development in the light of the Tennessee Valley Authority (T.V.A.) of U.S.A. Thus the Damodar Valley Corporation (D.V.C.) was set up in 1948.

The Damodar Valley Corporation proposed construction of eight dams on the rivers within the Damodar valley. These multipurpose dams were designed not only to control floods but also to provide water for irrigation and to generate hydroelectricity. Navigation and malaria control were also aimed at in the original plan. Eventually, however, only four dams, located at Tilaiya, Konar, Maithon and Panchet, were constructed between 1953 and 1959. A barrage was also constructed at Durgapur in 1955. A control dam was also constructed on Kangsabati (Kasai) river.

The Damodar valley project has no doubt achieved much of the goals originally targeted. The reservoirs of the four DVC dams together have a dead storage capacity of 525.5 million cu. m., and can hold up to 3590.9 million cu. m. of water to the top of the gates. The Maithon and Panchet dams, which are mainly responsible for flood control, together have a flood reserve of 1050 million cu. m. These two dams have controlled a number of major floods in the lower valley in recent years. The DVC dams together with the Durgapur barrage have also helped enormously in irrigating large areas of West Bengal and Bihar. The DVC thermal and hydel power plants have made large-scale electrification within the states of Bihar and West Bengal possible. This led to industrial development in places like Durgapur, Chittaranjan, Bokaro and Jamshedpur. More than seventy percent of coal mining in India is done with the help of the power generated by the DVC system. At least five major steel plants of the country get their power supply from DVC. The demands of the Eastern and South Eastern Railways are also substantially met from the same source.

On the negative side, it should be noted that the streams associated with the Damodar river system have not been completely free from flooding in recent past. The reasons for this are to be traced in excessive siltation within the dam reservoirs and the river channels. Published reports show that both dead and live storage capacities of the dams belonging to DVC have already been lost in alarming proportions due to siltation. Large-scale deforestation leading to soil erosion has been responsible for excessive siltation. Rapid industrialisation and expansion of human settlements had been the main reasons for deforestation. Unplanned blocking of the river channel for the purpose of pisciculture, particularly in the lower basin, has only added to the drainage problem.

There are two ways, flushing and dredging, by which the problem of siltation can be tackled now. Both the methods, unfortunately, are unacceptable in the Damodar valley. Flushing is not possible because a minimum amount of water has to be maintained in the reservoirs round the year for the purpose of irrigation and for generation of hydroelectricity. Moreover, flushing would create havoc among the human settlements that moved nearer to the river channel since the flood control system became effective. Dredging the silt out of the reservoirs is impracticable because this process increases the cross-sectional area of the canals thereby decreasing the carrying capacity of the streams. Moreover, dredging, an expensive operation, once started, has to be done repeatedly and frequently. Disposal of silt removed from such large areas poses additional problems. These problems leave no other way but to release surplus water from the DVC dams whenever it rains heavily in the catchment areas.

It may be recalled in this context that although in the original plan eight dams were envisaged in the Damodar Valley, in reality only four dams were constructed. Moreover, reservoirs of much larger size than what have been actually constructed were originally planned. These factors have considerably limited the storage capacity of the reservoirs. Heavy siltation has only added to the problem. Check dams constructed by DVC to restrict passage of silt into the reservoirs have also lost their effective capacity over the years. The DVC experience has taught us that it is essential to keep the dam reservoirs as well as check dams and canals associated with multipurpose river valley projects free from silt by periodic cleaning.

Settlements on the inner concave bank of a river should be discouraged because this area is particularly vulnerable to erosion. It should be remembered that like every living being a river also has its right to play within its own flood plain. If necessary, embankments should be constructed, not for restricting the movements of a river but with a view to preventing human beings from encroaching upon a river's natural domain. □