East Pakistan Floodplain Morphology

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Flood plains are interesting areas. Far from being monotonous and featureless, as often described by the traditional geomorphologist, these are characterized by a variety of interesting landforms. It is the purpose of this paper to describe the morphological characteristics of the East Pakistan flood plains and to explain some significant features in terms of fluvial processes operative in this area.

The Three Major Flood Plains (Fig. 1)

The major flood plains of East Pakistan are associated with the Ganges, Brahmaputra (locally called the Jamuna), and Meghna rivers. The Jamuna (Brahmaputra), which enters East Pakistan from the Assam valley and flows longitudinally, occupies the central position between the Ganges and the Meghna and is by far the dominant river of the region. The Ganges is close second but the Meghna is much smaller than the other two rivers.

The Ganges—The northern limit of the flood plain of the Lower Ganges River, in eastern India before it enters East Pakistan, is marked by the alluvial cones of its Himalayan tributaries, the most notable of which are the Kosi and the Mahananda, and in East Pakistan by the southern edge of the Barind Pleistocene terrace. The gigantic alluvial cones of the Himalayan rivers extend southward in a large area covering northern parts of the Indian states of Bihar and West Bengal. The Rajmahal Hills, close to the right bank of the river near the Rajmahal turn, form the southern limit of the Ganges flood plain. East of the Rajmahal turn the Ganges starts giving off distributaries on its right bank so that the flood plain is limited to the tract between the river and the Barind terrace on its left side.

Above the Rajmahal turn big bends are formed by the Ganges, but the channel shows braiding tendency. Below this point the bends are slight and the river has a single narrow channel up to Giria where three islands appear in the channel. Farther down between Godagari and Dumaria the banks of the Ganges consist of stiff clayey material, which yield little to the erosive action of the river. The channel is fixed here and has shown no signs of change for a long time, but near Rajshahi the sandy banks are easily washed away and channel shifting is a usual phenomenon. From Rajshahi to Goalundo, where occurs the Ganges-Jamuna confluence, bank caving and bar formation is constantly going on, and the channel shows a braiding tendency (Rizvi, 1956). The average gradient of the Ganges River in East Pakistan, as well as the slope of its levee crest, is about a foot per mile. Discharge measurements at the high stage during the last 30 years vary from 1.4 to 2.2 million cu. ft./sec. and show some degree of uniformity of maximum annual flow. Gauge records since 1910 indicate a variation of less than five feet between the highest and the lowest maximum water levels (Abbas, 1964). The absolute highest stage was recorded in 1910 when the estimated discharge

reached 3.0 million cu. ft./sec. Sedimentary discharge of the Ganges is estimated to be 350 to 400 million tons a year or about the same as that of the Mississippi River (Fisk, 1944).

The Jamuna—The Jamuna is the present channel of the Brahmaputra River in East Pakistan. The earlier course of the river, through which it flowed until 1779, is called the Old Brahmaputra, which still carries some water of the main river, especially during the monsoon season. The length of the river from the point it enters East Pakistan to its confluence with

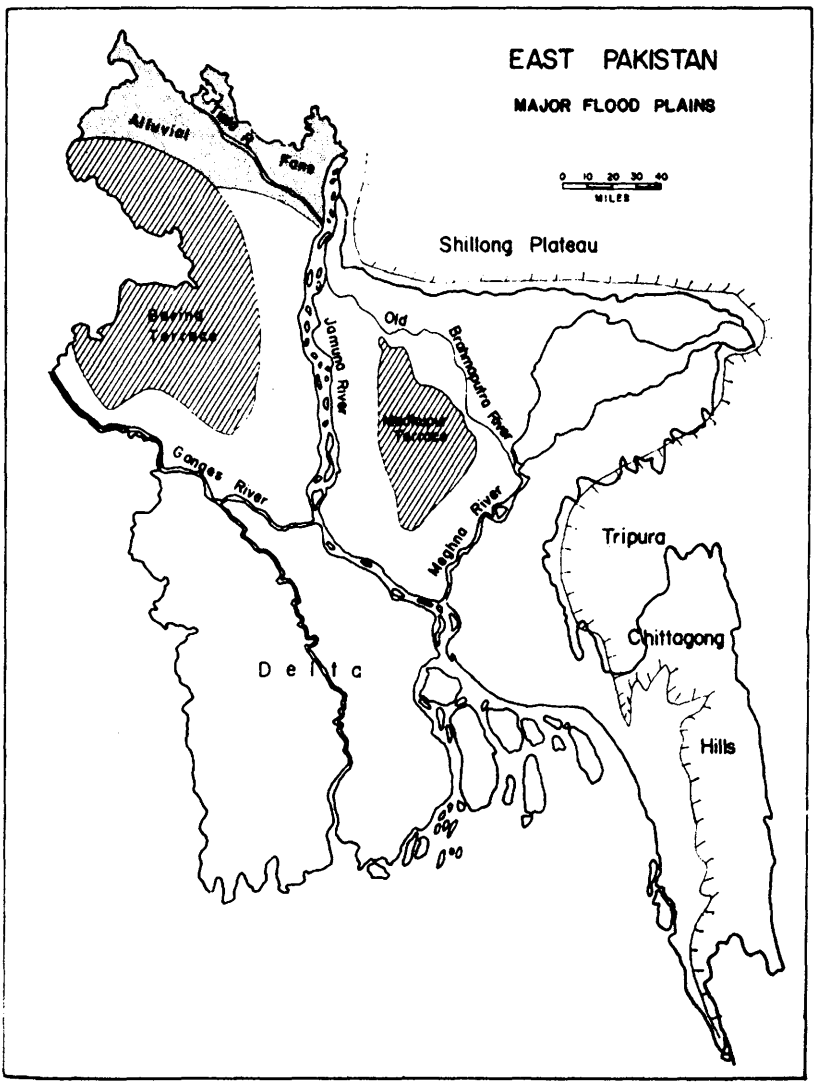

Fig. 1. East Pakistan major flood plains

the Ganges is 170 miles. For the rest of its 1800-mile course it traverses Tibet and the Indian state of Assam. The flood plain of the Jamuna is sharply delimited by the Pleistocene terraces on both sides. The river is located almost in the middle of a 35- to 40-mile wide plain between the Madhupur terrace on the east and the Baind terrace on the west.

By diverting its course into the present channel, less than 200 years ago, the Brahmaputra has captured a plain formed by a number of tributaries of the Ganges or the distributaries of the Brahmaputra. The topography produced by the earlier streams still can be identified although the Jamuna is actively engaged in modifying the forms and superimposing its own pattern over the earlier one.

Several older, prehistoric courses of the river also can be identified on air photos, topographic maps, and in the field farther east of the Old Brahmaputra. The Jamuna presents a sharp contrast from the older courses of the Brahmaputra in terms of channel patterns, sedimentary characteristics, and other morphological expressions. The old abandoned channels exhibit a pronounced tendency to meander, with a little braiding here and there. In most cases they have well-formed natural levees indicating a long period of occupation of each channel. Although some fine sand is found associated with channel fill deposits, natural levees, and point bars, these were essentially silt-carrying streams as exhibited by the fine-gained leveee material. These streams, when active, were also narrower and deeper than the Jamuna channel. The present course of the Brahmaputra is typically braided and is characterized by a wide and shallow channel with numerous sand bars and towheads. The load of the river consists of sediments which are now being deposited on parts of the captured flood plain. Natural levees are absent all along the Jamuna channel. As a result of its diversion into the Jamuna channel the Brahmaputra has changed from a silt-carrying, levee-building, narrow, and deep river to a sandy, wide, and shallow stream. The change in the sedimentary characteristics of the river can be partially explained with reference to the diversion of the Tista River, which abandoned its old southerly course to the Ganges in favor of a new southeasterly course which made it a tributary of the Jamuna. The Tista flows over the sandy alluvial fan surface of North Bengal and is one of the major contributaries of coarse sediments to the Jamuna. However, a considerable amount of sand is also derived by the Jamuna by eroding its banks. Sedimentary discharge of the river is estimated to be 700-1000 million tons a year or nearly twice the amount carried by the Ganges or the Mississippi. Gauge and discharge measurements were started in 1949 and 1956 respectively, and during this period a discharge of over 2.0 million cu. ft./sec. has been recorded several times. It is believed that the maximum discharge of the river is likely to exceed 3.0 million cu. ft./sec. (Abbas, 1965) (see Fig. 2).

The Meghna—The Meghna is the smallest of the three major streams with a drainage basin of more than 11,000 square miles in East Pakistan (Abbas, 1965). Its flood plain extends north-south from the base of Shillong Plateau to its confluence with the Ganges at Chandpur and between the Tripura-Chittagong ranges on the east and the Madhupur terrace on the west. It is a low-lying area and remains under water during the monsoon months when the Meghna and its tributaries overflow their banks. It is joined by the Old Brahmaputra and numerous clear-water streams coming out of Sylhet Jheel where they deposit most of their load. The eastern tributaries of the Meghna, rising in the Tripura Hills, have a short course and are responsible for supplying enough coarse material to the Meghna. The maximum flood stage discharge of the river varies from about 300,000 cu. ft./sec. to less than 500,000 cu. ft./sec. Its sedimentary discharge is estimated to be between one-third and one-half that of the Ganges.

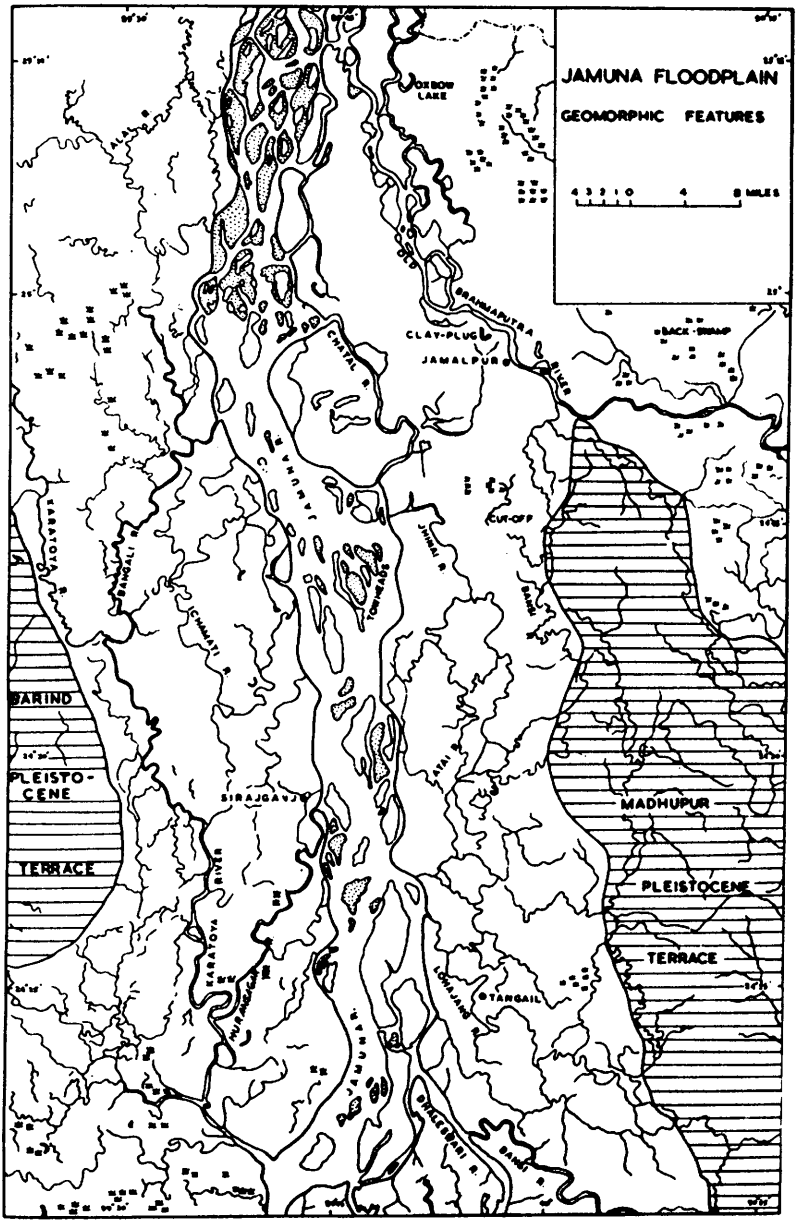

Fig. 2. Jamuna floodplain, geomorphic features

Processes and Forms

Channel Patterns—Channel pattern of the East Pakistan floodplain streams can be classified as braided and meandering. The braided streams have flat or nearly transverse profiles, devoid of the deep, narrow depressions called *thalwegs*, whereas the meandering streams have deeper channels and concave transverse profiles. A braided stream is characterized by channel complexity. It occupies many channels which entwine towheads and bars of various shapes and sizes. A meandering stream, on the other hand, occupies a single, simple channel except during the low flood stage when it may acquire some characteristics of a braided stream. The capacity of meandering streams to carry material is greater than the load they actually do carry, whereas the braided streams are almost always overloaded.

The braided streams are the most dominant type found in the flood plains of East Pakistan and are the chief agent of aggradation. The Jamuna-Bahmaputra is the classic example of a braided stream. The Ganges and also the Meghna meander broadly within their respective flood plains but display a fairly strong tendency to braid, especially during the flood stage. A number of small streams, especially in the Jamuna flood plain, may be considered as typically meandering streams.

Natural Levees and Backswamps—The alluvial ridges along the meandering streams, called natural levees, and the flanking depressions, termed backswamps, have characteristically developed along the Ganges and the Meghna rivers, whereas along the Jamuna they are conspicuously absent. The width and the height of the levees are proportional to the size of the channel. The average width of the Ganges levee, measured from the crest to the backswamp, is about a mile. The Meghna levees are about one-half of Ganges levees in width. The levees associated with the old, abandoned channels of the Brahmaputra are comparable to those of the Ganges and serve as excellent field indicators of the old courses of the great river.

A number of distributaries of the Old Brahmaputra, such as the Lohajang, Atai, Bansi, Jhinai, and others, carried a much greater volume of water before the Jamuna diversion than now. The levees built by these old distributaries, more than 200 years ago, indicate their former size. After the Jamuna diversion, and because they had no connection left with the master stream, they became underfit streams in their former channels. These underfit streams have a tendency to make a channel within the channel and to create a new meander pattern of their own. The meander curves of the underfit streams are very much smaller than the curves of the relict streams they occupy. The measurement of the meander loops of the deteriorated streams of the Jamuna flood plain indicates that they were undoubtedly made by streams of much larger size than the ones that occupy them at present. Within an airline distance of 16 miles the Lohajang River makes 20 meanders. Similarly, the Bansi River has 14 meanders within 14 miles. The Jhinai has 20 meanders within 14 miles. The highly sinuous Atai has approximately 30 meanders in 15 miles. The Lohajang, Bansi, Jhinai, and Atai have, thus, an average of one meander for a straight line distance of 0.8, 1.0, 0.7, and 0.5 mile, respectively. These meanders are apparently too large for the present streams and were made when they carried greater volume of water than they do now (Rasheed, 1964).

Fossil Levees—Natural levees are three-dimensional features. They extend not only upward and sideward but also downward as a result of compaction and subsidence. In an active river the annual deposition of sediments on the top of a levee compensates for the subsidence which takes place wthin a year. When the levees are no longer built up as a result of deterioration of the river, the levees continue to subside and gradually

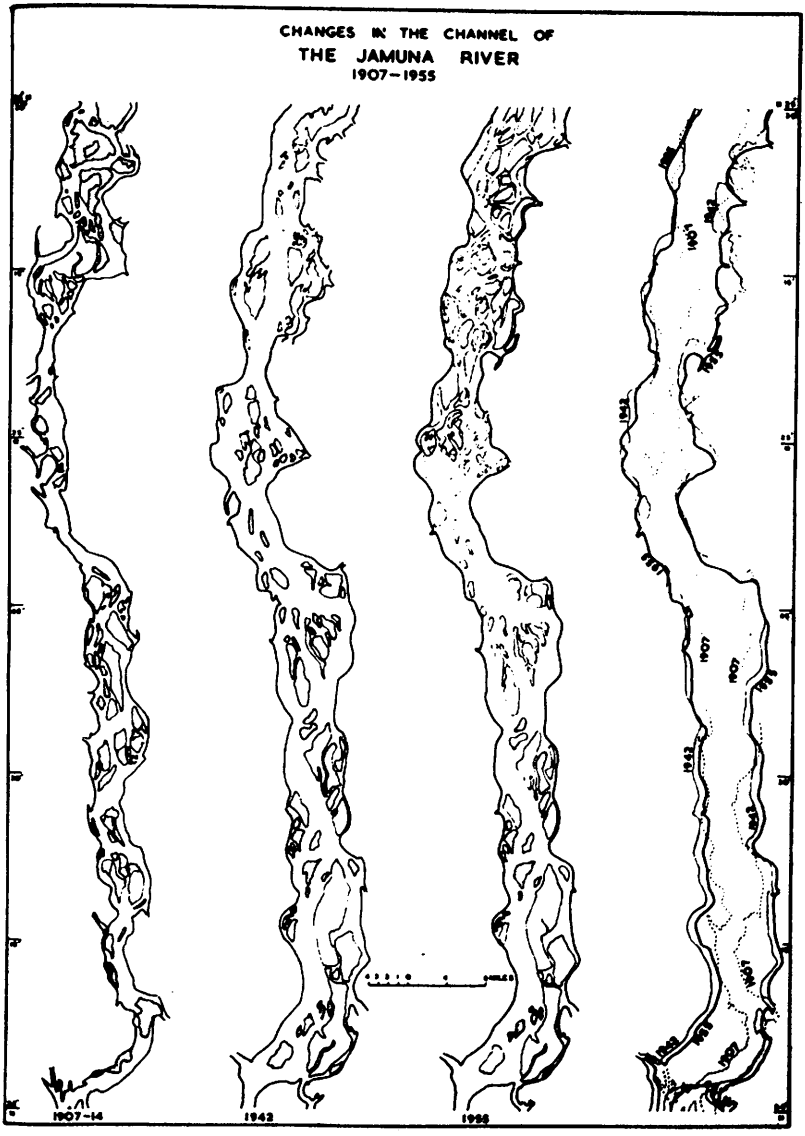

Fig. 3. Changes in the channel of the Jamuna River (1907-1955)

become inconspicuous. The levees associated with the old streams of the Jamuna flood plain are still a prominent feature on the surface and can be easily recognized in the field as well as on maps and air photos. The term *fossil levee* is introduced here to designate the levees of the old streams which have been gradually subsiding. Although the levee tops continue to rise above the general surface, their slopes are partially or wholly drowned in more recent alluvium. The fossil levees tend to rise abruptly from the sediments surrounding them and burying their slopes.

Bank Erosion and Channel Widening—A comparison of maps prepared by the survey of Pakistan and Directorate of Land Records of East Pakistan showing the positions of the Jamuna channel in 1907, 1942, and 1955 reveals a general widening of the river throughout its East Pakistan course. The width of the channel, as measured from one bank to another across the sand bars, varied from a minimum of 1.6 miles to 6.4 miles in 1907. The minimum and maximum width in 1955 became 3.2 and 9.6 miles respectively. In less than fifty years the average width of the channel has increased from 3.46 miles to 6.52 miles. However, the process of channel widening was most active up to 1942; since then the channel exhibits a comparative stability. During the 13-year period from 1942 to 1955 the average width has increased by 0.04 mile only, which shows a much lower rate of erosion (see Fig 3).

Bank erosion in the Jamuna is more active at the time of falling flood than at high stage time. At bank-full stage the river has a tendency to deepen its channel by eroding the bars deposited in the last season. Bank recession is also a function of caving and slumping rather than the so-called lateral planation.

The study of alluvial morphology in East Pakistan is still in its infancy. The three great flood plains together with the combined delta of the Ganges and Brahmaputra form one of the largest alluvial areas of the world and offer a unique opportunity to a student of fluvial processes and forms. It calls for team effort and international cooperation among scientists.

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LITERATURE CITED

Abbas, B. M. 1964. Control of floods in East Pakistan, Oriental Geographer, 8:105-116.

Fisk, Harold N. 1944. *Geological Investigation of the Alluvial Valley of the Lower Mississippi River*. Vicksburg: Mississippi River Commission.

Rasheed, Harunur. 1964. *Agricultural Occupance in the Jamuna Flood Plain in Mymensing District*, unpubl. Master's thesis, Univ. Dacca, Pakistan.

Rizvi, A. I. H. 1956. The Changing Drainage Patterns of the Lower Ganges Valley, Dacca Univ. Stud., 8:152-167.