EIR Science & Technology

Flood control in Bangladesh: a big engineering challenge

Three mighty rivers pump vast sheets of silt-laden water into this huge delta, causing floods and destruction. Ramtanu Maitra, the editor of Fusion Asia, *presents possible solutions.*

Editor's Note: Ramtanu Maitra here gives an overview of the problems of flooding in Bangladesh, and in the watershed of the Ganga (Ganges), Brahmaputra, and the Meghna rivers in general. The approaches on which he reports are delimited by the constraints imposed on the building of great projects, by institutions such as the International Monetary Fund (IMF) and the World Bank. Not only do these institutions themselves withhold credits for such programs, but they also vector the flows of government and private bank finances in an opposing direction.

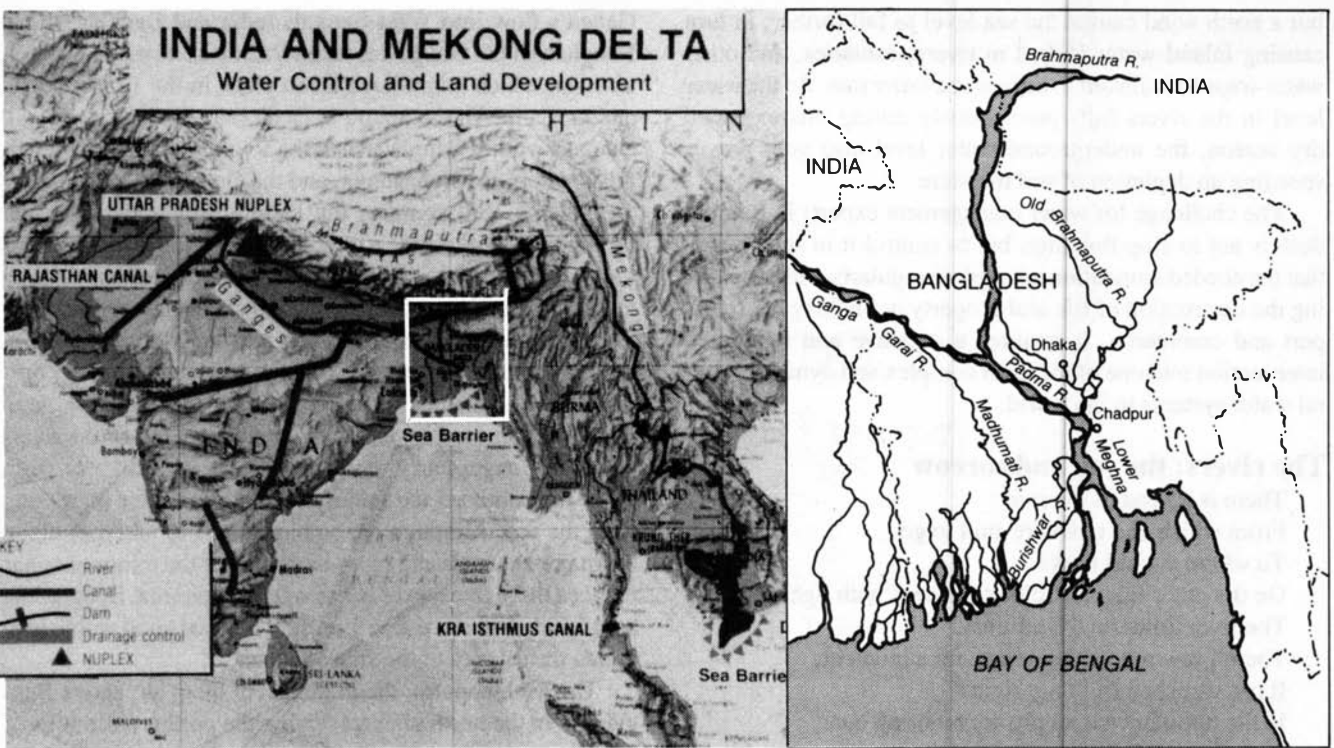
One crucial element in any large water development project is the dredging of canals. Key to accomplishing this economically and speedily, is the use of small atomic bombs, known as peaceful nuclear explosives (PNEs). In 1979, the Fusion Energy Foundation (FEF) drafted a program for such large-scale water development, drawing upon the concepts of Dr. K.L. Rao, a former irrigation and power minister in India, who in 1972 drafted a comprehensive Ganga revitalization and Brahmaputra control plan. His plan looked forward to the production of an additional 1 billion tons of food grains annually, or eight times the level reported in 1986, with 130 million hectares of land under irrigation, three times the 1986 level. He foresaw the production of 40 gigawatts of new hydroelectric capacity, compared to 5 gigawatts presently.

The plan developed by the FEF would be accomplished in two 15-year stages, and would begin with a canal diverting the Brahmaputra near Dhubri to the Ganga near Patna. This canal would include outlets for irrigation releases to Bangladesh en route. A second diversion canal would be built from the upper Ganga and Yamuna rivers in Haryana (north of Delhi) with groundwater recharge and extraction facilites en route to convey surplus water into the Sutlez Basin for delivery into the Western Desert through an enlarged Rajasthan Canal. Near Bikaner in western Rajasthan, a pump-lift canal facility would convey Himalayan water to the porous sandstone aquifers about 105 kilometers northeast of Jodhpur as a regulating storage facility. That water now runs off either through the Ganga tributaries or those of the Indus River.

These canal systems would be augmented by groundwater recharge and extraction systems, using PNEs, required to impound the massive monsoon runoff during the July-October season, especially in the Ganga delta area, where about 65% of all India's water runoff occurs. Use of the PNEs as well as radial wells can double the country's groundwater storage capacity.

Finally, a seawater barrier at the mouth of the Ganga for flood control and improved navigability is a priority. A master plan for this was prepared by the International Engineering Company of San Francisco 25 years ago, and in fact, has been partially used as a guide by the Bangladesh government. Nonetheless, IMF conditionalities have prevented the Bangladesh government from proceeding on the required scale.

The second stage of the FEF plan involves extending the canal system southward through the subcontinent—the so-called Ganga-Cauvery link canal. This canal would stretch along eastern India from Patna to the Cauvery River in the far south, with an ultimate capacity of 24 billion cubic meters



per year, ten times greater than the original plan estimated by Mr. Rao. Estimates for the costs of the system were $80 billion for Phase 1 (in 1986 dollars) and $100 billion for Phase 2.—Carol White

Introduction

Located in the watershed of three great rivers of South Asia—the Ganga, the Brahmaputra, and the Meghna—Bangladesh is a large delta. The gently sloping land, from the north in the foothills of the Himalayas to the south where wet flatlands lead to the muddy waters of the Bay of Bengal, serves as a large floodplain through which most of the waters from the Himalayan mountains' watershed pass into the sea. Swollen by intense rainfall and periodic cyclones during the monsoon season, three mighty rivers pump vast sheets of silt-laden water, causing floods and destruction.

Bangladesh, the youngest South Asian nation, which broke away from Pakistan in 1971 to become independent, has a land area of 55,598 square miles where more than 110 million people live. The deltaic plain of Bangladesh, which is inundated with clocklike regularity at the end of August every year, covers about 30,000 square miles, a little more than half of the entire country. This includes 19 million acres of excellent paddy land, most of it no more than 20 meters above sea level.

Living in a riverine country, the people of Bangladesh depend heavily on the waterways for a cheap and convenient mode of transportation. The main arteries of this waterway system—which is nearly 8,500 miles long, with 3,245 miles navigable all year round—link almost all the inland port cities and important commercial centers within the country. During the flood season, traffic and commerce in the country come to a virtual standstill. During the southwest monsoon period, when heavy rainfall in the higher altitudes upstream and in the plain swells the rivers, the entire deltaic plain of Bangladesh is submerged, causing loss of property, human lives, and foodgrains.

Although the floodwater causes significant damage to the *aus* and *aman* paddy (the early and late monsoon plantings, respectively), the loss is often made up by an exceptionally good *boro* (dry season) rice crop. This is because the inundation during the floods helps the soil preserve moisture, which inspires farmers to plant more area, taking advantage of the better soil and moisture conditions. This phenomenon was observed following both the 1987 and 1988 floods, considered the worst on record.

This highlights Bangladesh's dilemma: the floods are its bane and its boon. Crossed by the second largest river system in the world, and many lesser streams, and receiving rainfall at rates among the world's highest, Bangladesh nevertheless suffers acutely from severe shortages of water. While the floods can, and often do cause enormous amount of material damage, inundation of the country's flat delta plains is absolutely necessary to restore the usable water in the vast groundwater aquifers and to build up adequate moisture in the soil to produce a bumper harvest in the dry season.

During the seven-month-long period of no rains, not only does moisture evaporation take place at a much faster rate, but a north wind causes the sea level to fall further, in turn causing inland water locked in rivers, estuaries, and other water-traps to drain out to the sea at a faster rate. As the water level in the rivers falls precipitously during this extended dry season, the underground water level also goes down, speeding up depletion of soil moisture.

The challenge for water management experts in Bangladesh is not to stop flooding, but to control it in such a way that the needed inundation takes place regularly without causing the destruction of life and property or choking off transport and commerce. It requires a sensitive and fine-tuned intervention into one of the most complex and dynamic natural water systems in the world.

The rivers: the joy and sorrow

There is no end of the river:
From which end to where am I to go,
To whom should I ask!
On the other side dark cloud thickens with lightning;
The river flows on the torrents,
There I saw my golden image for a moment,
It has vanished from my sight.
In the turbulent river I ply my tottering boat,
In the hope that I may meet my
Beloved in the journey's end.
—*Bangladeshi boatman's song*

There is a belief among many in the West that no one in South Asia really appreciates the abundance of water, a gift of God, that the region has. There is concern that such a valuable treasure is allowed to flow to the sea unhindered and unutilized. Unfortunately, this well-intended concern is more often than not associated with a complete lack of comprehension of the scale and complex dynamics of this natural water system. As a result, the problem of how to manage this huge water system for the safety and benefit of increasing numbers of human beings remains an unanswered question. To answer it means, first of all, grasping the magnitude of the system and its components.

The Ganga, Brahmaputra, and Meghna rivers combine to form a river that is two and one-half times the size of the Mississippi. Although the total area of the South Asian watershed is slightly less than one-half the area of the central basin of the United States, it receives *four times* the Mississippi basin's total annual rainfall, 85% of it in just four months of the year. From the highest mountains in the world and from the earthquake-prone foothill jungles that include sites receiving the highest annual rainfall in the world, the descending waters carry more than 2 billion tons of silt each year. Under such conditions, no work of clearing or channeling can be considered remotely stable or permanent.

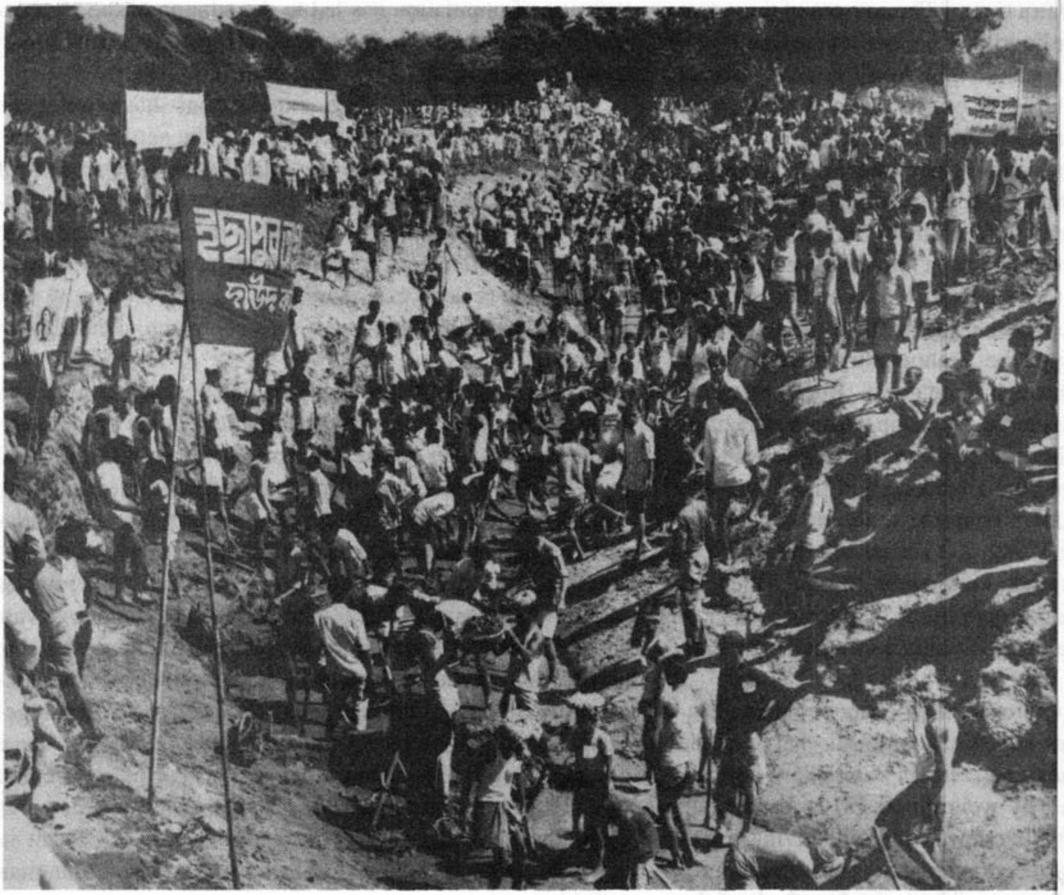
The Ganga, which along with its major tributaries brings flood disasters annually to the plains of India, enters Bangladesh near Farakka. There a barrage has been built to divert Ganga's flow into West Bengal, India and Bangladesh. In Bangladesh the Ganga has taken Padma as its main channel, an event which might have taken place in the 17th century, and meets the Brahmaputra at Goalondo. Its important spill channels within Bangladesh in the south include the Jolongi, the Bhairab, the Nabaganga, and the Gorai.

Till the 18th century, the Padma discharged its water through the Arial Khan, a river in the down stream which has today become practically dry and carries water only during the monsoon. The gradual movement of the mainstream of the Ganga toward the east, ultimately joining with the Meghna, has helped to dry up the spill channels which now lie dry during the dry season. This has caused the gradual increase in sterility of the land in the southernmost reaches of the rivers which no longer carry any considerable discharge of fresh water to counteract the salinity of the tidal waters ingressing from the sea. Although the embankments of all types along the major channels and cross-damming of the minor ones has reduced the ingression of saline water in this area, Bangladesh has already lost more than 1 million acres of good arable land due to the salinity of the subsoil water.

The Brahmaputra, the mightiest of them all, enters Bangladesh in the north after traversing the northern foothills of the Himalayas for some 1,500 miles. In northern Bangladesh, the Brahmaputra's silt-laden waters overflow their own banks and cause the tributaries to overflow as well. Where it meets the Meghna, the Brahmaputra spills over its banks and feeds a number of spill channels such as the Old Brahmaputra, Dhaleshwari, Lohajung, and others. These spill channels, during peak discharge, also spill over their banks because of their inadequate size and insufficient surface slope.

The diversion of the Brahmaputra to its present course, joining the Padma near Gaolondo, took place toward the end of the 18th century or beginning of the 19th century. The mainstream of the river had passed through the old channel for several centuries. The diversion was caused by the silting up and raising of the river bed due to the slowing down of the flow, which also reduced further the surface slope over the decades. During the last 150 years or so the banks of the Old Brahmaputra—like many other "dry" rivers and spill channels—have become the habitat of many on account of their relatively higher elevation. Villages with permanent structures have come up which could be devastated, should the Old Brahmaputra be revived.

The Meghna, by contrast, is not as great a delta builder as the Ganga and Brahmaputra. But it occupies a very important position in the riverine economy of the country. This river and its tributaries serve a very broad basin comprising the districts of Sylhet, Mymensingh, Tippera, and a part of Dhaka and Noakhali. The land area between the Brahmaputra and the Meghna, known as *doab,* receives copious flood discharges from all sides, which the Meghna is unable to drain off satisfactorily. As a result, the area gets inundated by an early flood. Sometimes there is protracted flooding,



A canal excavation project in Bangladesh about a decade ago. The annual floods are the country's bane and boon, since Bangladesh also suffers acute water shortages.

and the area is occasionally subjected to a quick rise in flood level—all of which are deleterious to the rice crop. The Meghna lost a considerable surface slope long ago by the combined discharge of the Brahmaputra and the Ganga, causing a heading up of the Meghna level at Chandpur.

The waters of these three mighty rivers converge at Chandpur and flow south from that point in a combined stream. The ferocity of this stream at its peak discharge level cannot be overestimated. In a recent "normal" shift of a lower combined section of the stream, the river moved its course eastward in a matter of days by half a mile in front of the port city of Chandpur! It cut an altogether new east bank channel about 45 meters deep, joining that land to its sediment load and carrying it out toward the sea. No embankments or river-training works in the world can control these forces head-on.

The floods: an annual event

In the moon the sand stretches to the distant horizon,
In the sun the heart burns and tosses with thirst,
O Allah, give us clouds and rains and shade.
The sky has cracked, the earth is parched,
The king of clouds is sleeping,
Who will give you rains?
—*From the Bangladeshi* Jari *folksong*

While the floods in Bangladesh draw international attention, few realize that some 60% of its agricultural land lies fallow for five months during the dry season, a time when severe water shortages prevail. At the same time, nowhere in the world with the exception perhaps of China, is the cropland under greater pressure to produce food. Average population density in Bangladesh, now at about 2,000 per square mile, is the highest for any nation with a significant population size.

This feast-and-famine water syndrome characterizes the monsoon climate. With the change of season in August, almost half of Bangladesh becomes one vast sheet of water, almost a meter deep. Where does the water come from? The Ganga-Brahmaputra watershed enjoys an overall average of 60 inches of rainfall a year, most of it in a short several months' period of time. In general, annual rainfall decreases as one moves west; from 120 inches at the Bangladesh coast, to 20 inches in India's Rajasthan in the extreme west, and 18 inches in Lhasa, Tibet, in the rainshadow of the Himalayas.

Besides, in the cold heights of the Himalayas there are large deposits of water in the form of ice. Permanent ice covers an estimated 30,000 square kilometers in the Himalayas, 17% of the total area of the range. These glaciated heights, along with those of Tibet to the north, give rise to the Ganga and Brahmaputra rivers. The sources of these two mighty rivers are extraordinarily close, before the Ganga and Brahmaputra begin their parallel eastward courses, one to the south and one to the north of the Himalayas, to meet within a few miles of the sea in the Bengal delta.

Originating in southwestern Tibet where it is known as the Tsang-Po, the Brahmaputra flows eastward for 1,625 kilometers along the northern foothills of the Himalayas before swinging sharply south and west into the state of Arunachal Pradesh in India. Out of its 2,906 kilometer journey beginning at the Kanglung Kang glacier to its final destination in the Bay of Bengal, the Brahmaputra traverses only the last 363 kilometers through Bangladesh. But by that time it has become a monstrous force. Once the Brahmaputra turns the bend and enters India, it is met by huge tributaries such as the Dihang, the Lohit, the Dhansiri, and the Subansiri, among others, coming down from the southern slope of the Himalayas. Of the river's 580,000 square kilometer catchment area, 293,000 square kilometers lies in Tibet, as 195,000 square kilometers lies in India, 45,000 square kilometers in Bhutan and just 47,000 square kilometers in Bangladesh.

The Brahmaputra's explosive flow characteristics virtually defy taming. The high silt content of the discharge (some recent observations at the point it enters Bangladesh indicate that the proportion of silt by weight is 0.13) is responsible for its brisk activity in making new islands and giving rise to new sand banks during the dry season. These temporary formations are then washed away with the first flush of the monsoon. The width of the river is sometimes as much as 12 miles, the average being five miles.

In addition, the Brahmaputra carries a very high discharge during its peak flow. On an average, the peak flow is about 2.6 million cubic feet per second. To get an idea of what this means: The total volume of water consumed daily in the city of Tokyo is equivalent to just four minutes' peak flow of the Brahmaputra!

But it is the fact that the high flood levels of all three rivers coincide in mid-flood season in late August that makes flooding throughout the delta inevitable. Were the Brahmaputra, for instance, flowing at a lower level at that time, the Meghna and its tributaries could be quickly flushed and flooding reduced in the entire land area between Meghna and Brahmaputra.

The growing menace of the floods in the subcontinent is frequently attributed to deforestation in the Himalayas. It has also been alleged that embankment works upstream to prevent spilling of riverwater has added to the flood discharges. It is argued that deforestation of the Himalayas has caused an increase in rapid and direct runoff of precipitation during the monsoon, and siltation and reduced streamflow during the dry season, which in turn are identified as the primary causes of increased flooding on the Brahamputra and Ganga plains. According to this line of thinking, the growing pressure of population has led to denudation of the Himalayas, and an expensive, large-scale afforestation program in the mountains is the only way to control floods.

Though plausible, such explanations have not been backed with concrete evidence. In fact, the natural sedimentation of the streams from the Himalayas, independent of deforestation and human settlement, is massive. Over geologic time, such sediment has filled the Gangetic plain to depths of 2,000 meters or more. A broad sediment fan up to 12,000 meters deep extending into the Bay of Bengal well south of Sri Lanka has been created in the same natural process.

There is at least one study, by James M. Coleman in 1969, which shows a remarkable stability in the broad range of the braided river courses (13 to 19 kilometers) from 1830 to 1963. From this, and from some other studies, one can conclude that there is no evidence to support any *direct* relationship between man-caused landscape changes in the Himalayas and changes in the hydrology and sediment transfer in rivers in the plains. The Himalaya-plains system is so vast and dynamic, and is dominated by such immense erosive processes from the geologically young mountains, that natural processes alone are sufficient to account for the large-scale runoff and sedimentation patterns. According to some experts, even micro-scale events such as periodic torrential rainfalls in specific areas or such specialized processes as the outburst of glacial lakes, are often more important in determining flood patterns than the negative effects of human activities.

What is certainly the case is that the increased population density, and accompanying economic activity, in Bangladesh's floodplain over the past century has made it more and more urgent to find a way to control the annual floods.

Flood control measures: a conceptual approach

Over the years, a number of suggestions have surfaced on how to deal with the floods in Bangladesh, some narrow and specific and others grand and structural. But so far, none has been subjected to rigorous physical feasibility studies. The discussions have mostly centered around three basic approaches: 1) reduction of floodwaters through surface or underground storage of water; 2) diversion of floodwaters by building embankments and drainage facilities; and 3) reduction of flood damage by improving warning systems and providing "flood proofing."

The first approach calls for building upstream storage reservoirs to hold back water during the peak flow season and release it during the dry season. One estimate by J.S. Colombi in 1988 shows that between India and Nepal, a maximum storage capacity of 225 billion cubic meters is feasible. But this will take 50-60 years to create and, if the present cost of dam-building is considered a cost indicator, it would cost anywhere from $500-800 billion in 1988 dollars.

Colombi estimated that such storage facilities would reduce the flood peak in Bangladesh by about 0.4 meters. According to another expert, the reduction in flood height would be much less, more like 0.2 meters.

Neither figure makes a significant dent in the meter-high peak flood. And to the extent that underground storage is involved, there are additional costs, in that these systems have to be maintained by increasing pumping of water during the dry season and allowing groundwater aquifers to fill during the monsoon.

The second approach, to divert floodwaters through building embankments and drainage systems, is widely used the world over, and in fact Bangladesh already possesses a significant length of embankments. There are, in turn, several different conceptual approaches to building embankments. The first is to contain the river on both sides throughout its length. The second is to allow the river to overflow into areas either considered not important, or where inundation is deemed necessary for agriculture. The third approach is to provide embankments only to protect the cities and commercial centers. In the last case, the actual length and height of construction works are much less than for full river embankments, and hence, less expensive.

All of these approaches, however, have distinct limitations. In the case of the full river embankment approach, land on either side of the river does not receive the floodwaters essential for filling up underground aquifers, thus making the land less productive during the dry season. Also, in case the floodwater does spill over the embankment, it cannot be drained out—a situation which creates water stagnation and large-scale material damage.

Floods can also be abated through developing an efficient drainage system. Rivers like the Brahmaputra and the Ganga which carry a large amount of silt that is deposited on riverbeds during the low-flow season can be kept relatively sediment-free through dredging. But this can be an extremely expensive proposition for rivers as silt-laden as the Ganga and Brahmaputra. This approach has been adopted in the United States, on a much smaller scale, where the Mississippi is dredged annually at an expense of some $10 million. The Mississippi, however, carries much less silt than either the Ganga or the Brahmaputra.

It is estimated that dredging of some major spill channels such as the Gorai and the Arial Khan can reduce the flow of the Padma downstream by another 100,000 m^3 per second. Similar dredging efforts could reduce another 100,000 m^3 per second around the junction of the Brahmaputra and Ganga. These are, however, small numbers in the face of the 5 million m^3 per second flowing in the joined Ganga and Brahmaputra during the high flood season.

Flooding can also be reduced in the lower reaches of the basin through land drainage. Obstacles to this, such as road and railroad embankments, need to be carefully laid out with drainage culverts of appropriate sizes. Wherever possible natural drainage must be kept intact, and some man-made flood bypasses could be constructed. The southern bank of the Padma, for example, is a naturally low-lying area and could be made into a flood bypass with a small amount of excavation and river-training works.

Reducing flood damages through "flood proofing" entails an improvement of warning systems and creation of elevated refuges near the flood-prone villages that are equipped with food and medical supplies. The purpose is to reduce the loss of human life during flood. The Bangladesh government has already endorsed numerous flood-proofing policies in its "Guiding Principles" on flood management, implemented in November 1988.

Flood-proofing also involves building roads at a level much higher than the flood peak level; protecting such essential utilities as power-generation equipment and water pumps by installing them at a much higher elevation; using flood-resistant materials in buildings up to the highest possible flood level; and, building low dikes around sensitive crops, among other things.

In the end, the answer to Bangladesh's dilemma probably lies in the right combination of all three basic approaches.